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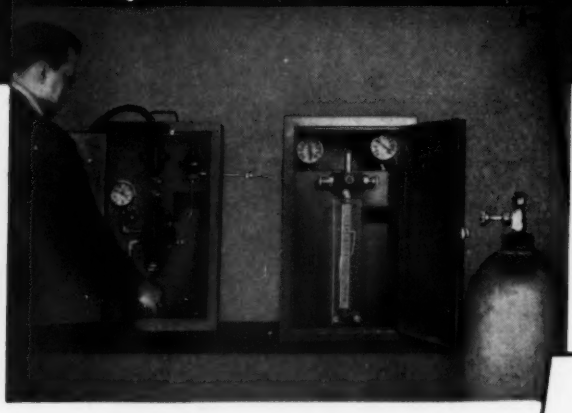

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Graphical Methods for Indicating the Mineral Character of Natural Waters

By Wilfred F. Langelier and Harvey F. Ludwig

IN THE solution of problems involving mineral analyses of natural waters, particularly in the fields of geology, agriculture and engineering, it is often desirable to classify waters on the basis of their major chemical constituents. These constituents fall into four groups, each with chemically similar components: c_1—the alkali cations, sodium and potassium; c_2—the hardness cations, calcium and magnesium; a_1—the strong acid anions, nitrate, chloride, and sulfate; and a_2—the weak acid anions, carbonate and bicarbonate. If the concentrations are expressed in terms of normality (equivalent hydrogen) or some convenient fraction thereof, e.g., milligram equivalents per liter (mE/l.),* the mineral character of the water is indicated by the total equivalent concentration, i.e., the total concentration of alkali and hardness constituents (Σ), and by the relative

A contribution by Wilfred F. Langelier, Prof. of San. Eng., and Harvey F. Ludwig, Graduate Student in San. Eng., Univ. of California, Berkeley, Calif.

* The unit "equivalents per million grams" (epm.), tentatively approved by the American Society for Testing Materials in 1940 (1), appears to be more consistent when used together with the firmly established "parts per million" (ppm.), because each is a "weight per weight" unit. The abbreviation (epm.), however, introduces a serious inconsistency in that the letter *m* stands for "million grams" rather than for "million equivalents" as might be inferred from its significance in the term (ppm.). Because of this, and also because, in the use of weight per weight units, it is not always clear whether weights of *solution* or weights of *solvent* is meant, the authors prefer to use the weight per volume units, i.e. milligrams per liter (mg./l.) and milligram equivalents per liter (mE/l.). Each of these is consistent with the other; and in the case of saline waters, there can be no uncertainty as to whether or not a specific gravity correction has been applied.

magnitude of each constituent expressed as a percentage of Σ. In this method of grouping, based upon the work of Palmer (2), the slightly dissociated silicic and carbonic acids, trace elements, etc., are omitted from consideration. Since the electrical neutrality of solutions of salts requires that $c_1 + c_2 = a_1 + a_2$, it is necessary to determine only three of the groups in the laboratory, the value of the fourth being obtainable by calculation.

Asserting that, for purposes of geological classification, greater importance attaches to relative proportions of constituents than to absolute concentrations, Palmer bases his classifications upon "percentage of total" values for the cation and anion groups respectively. By expressing

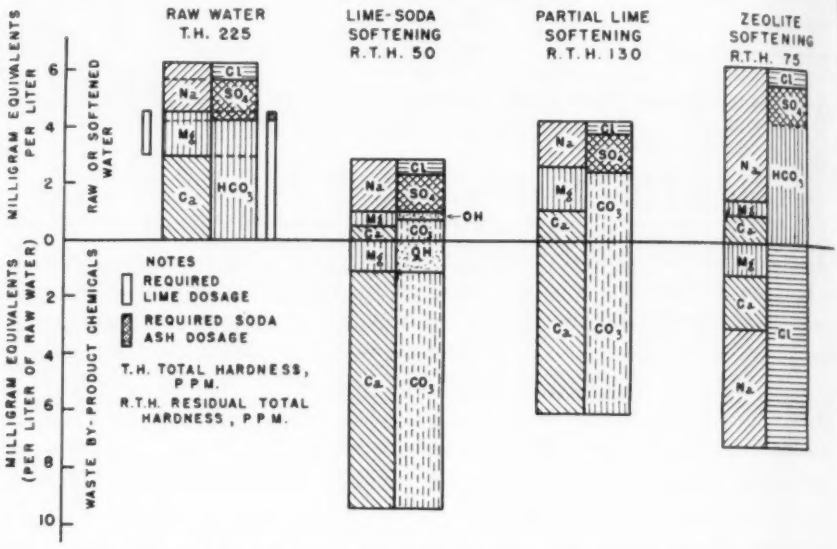


FIG. 1. Double-Bar Graphs, for visualizing chemical arithmetic of three proposed treatments for softening water from Corralitos Creek, Watsonville, Calif.

the results of an analysis in this form and by assuming balances between cations and anions in accordance with a prescribed order, a "character formula" of the water is obtained. In the Palmer system, the alkali and hardness cations are termed primary and secondary respectively. The non-carbonate and carbonate anions are termed salinity and alkalinity respectively. The property of primary salinity results from the presence of the c_1 and a_1 groups. If the former group is in excess, the property of primary alkalinity is also indicated. If, however, the latter group is in excess, the property of primary alkalinity is absent, and, instead, the property of secondary salinity is indicated. The property of secondary alkalinity results from the presence of the c_2 and a_2 groups. Thus, there

are four properties, but not more than three are represented in a given water. Palmer includes those waters which possess primary alkalinity in Class 1, and those which possess the property of secondary salinity in Class 3. Class 2 is reserved for those rare waters in which the c_1 group is exactly equal to a_1, and Class 4 for those equally rare waters in which c_2 is exactly equal to a_2.

By thus reducing the number of items of a water analysis into a smaller number of similarly reacting groups, the use of graphs and diagrams to indicate mineral character becomes practicable. Various types of graphs are possible; and these are especially useful when it is desired to compare the results of a number of analyses, or to ascertain the changes in character which a body of water undergoes as a result either of mixture with other waters under conditions of natural flow or of chemical treatment as in water softening. For these purposes, tabulated data are difficult to visualize, and the possibilities of classification are not so readily apparent. It is the purpose of the present paper to review this subject and to explore new possibilities.

Double-Bar Graphs

Perhaps the most widely used graphs designed to depict the mineral character of water are the double-bar graphs similar to those shown in Fig. 1. Graphs of this general type are believed to have been described first by Collins (3). The several graphs in Fig. 1 were prepared to illustrate the changes in character which a water would undergo as a result of softening by three indicated treatments. It will be noted that in these graphs much of the chemical arithmetic* of the three processes is visualized. The by-

* The dosages of lime and soda ash indicated assume the absence of free carbon dioxide. In this process the magnesium is precipitated as insoluble hydroxide and the calcium as insoluble carbonate. Since the precipitation of magnesium as hydroxide requires the presence of OH ions in excess of the concentration that can exist in the presence of the weakly acid HCO_3 ions present in the water, the latter must be first neutralized to CO_3 ions. Since in this neutralization, each equivalent of HCO_3 produces two equivalents of CO_3, these latter become available to precipitate not only the calcium added in the form of lime but a portion or all of the calcium present in the water. Additional CO_3 ions in the form of Na_2CO_3 will be necessary only in the amount that Ca + Mg is greater than HCO_3, or that Cl + SO_4 is greater than Na.

In the example used for illustration, or in the softening of any water in which the chloride plus sulfate exceeds sodium, the use of NaOH to supply the deficiency of sodium will not only replace the Na_2CO_3 commonly used but will also reduce the lime requirement by the same amount. Normally, however, there would be no saving in cost resulting from this substitution because an equivalent weight of caustic soda would cost more than one equivalent weight each of soda ash and lime (see Arbatsky Method, p. 339).

products of the chemical reactions, those substances for which adequate disposal facilities must be available, are shown in the graphs. To convert the indicated milligram equivalent weights into pounds per million gallons of water treated it is necessary merely to multiply the scale differences for any constituent by its equivalent weight and by 8.34, the weight of a gallon of water. A conversion chart (Fig. 2) can be used to facilitate these computations.

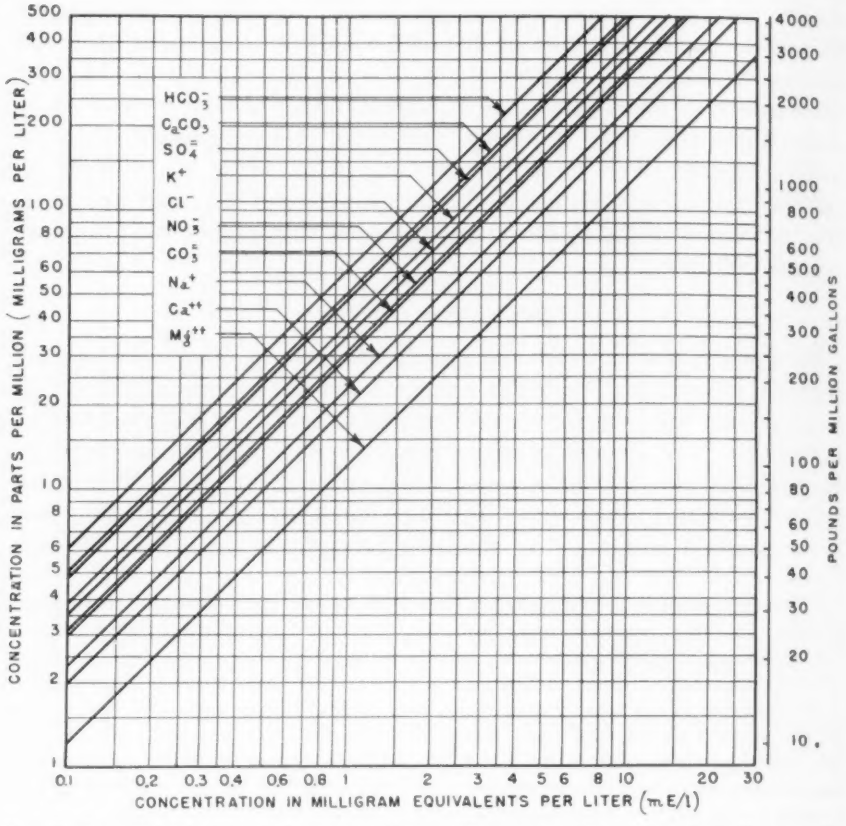


FIG. 2. Logarithmic Chart, for converting milligrams per liter (ppm.), or lb. per mil. gal., into milligram equivalents per liter (mE/l.), or the reverse

If desired, the double-bar type of graph can be used to indicate directly both the relative and absolute concentrations. In this modification the percentage equivalent concentration of each constituent is plotted vertically, and the total equivalent concentration is indicated by the width of the double bars. This modification has been described by Stabler (5).

Point Diagrams

In recent years, graphing techniques by means of which the character of one or more waters is indicated by the location of points upon suitably constructed diagrams have been described in the literature. The more

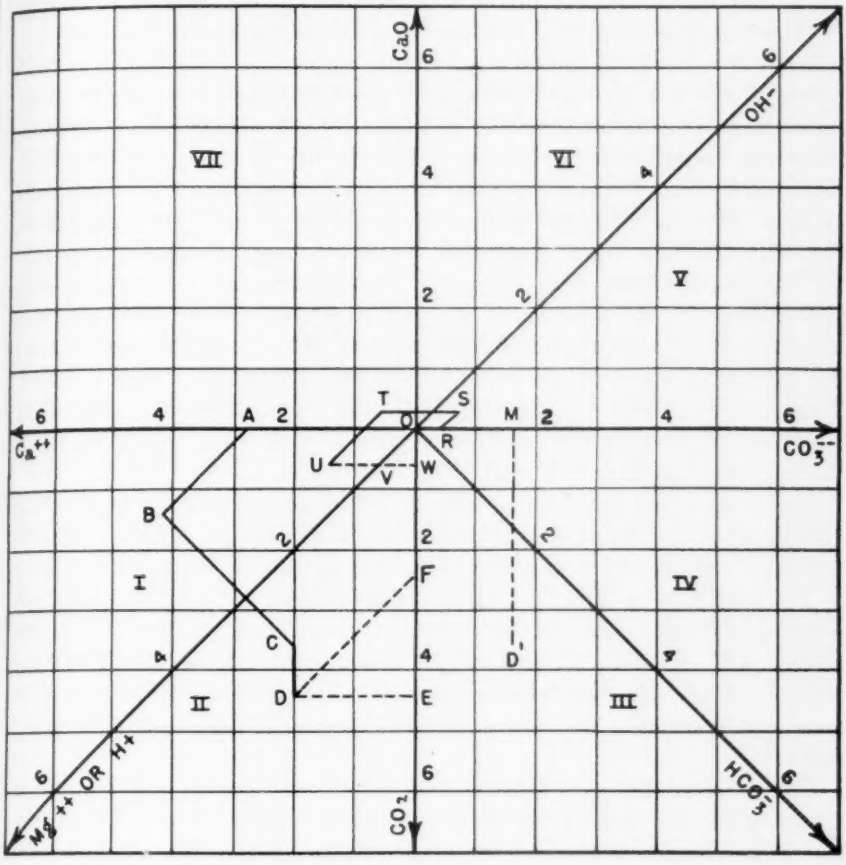


FIG. 3. Two Examples of Use of Arbatsky Vector Diagram, in graphical computation of lime and soda requirements in water softening

important of these will be reviewed together with two new forms proposed by the authors.

Arbatsky Method

This method (4) was developed and is primarily useful in connection with the lime-soda or other precipitation methods of water softening. It

makes use of a vector diagram in which incompatible substances, whether present in the water or used in the process of treatment, are plotted on opposite axes in such manner as to indicate directly the quantities of chemicals necessary for softening or, in the case of a softened water, the correctness of the dosages applied.

The method will be understood by reference to an example shown in Fig. 3. Here the hardness characteristics of a raw water are indicated by the location of point *D* in sector II, obtained by scaling the equivalent concentrations of Ca, Mg, HCO_3 and H_2CO_3 each in a direction parallel to its vector axis, i.e., along lines *OA-AB-BC-CD*. It will be seen that this water can be softened by treatment with additions of Na_2CO_3 and CaO indicated by lines *DE* and *EO* respectively or by NaOH and CaO indicated by lines *DF* and *FO* respectively. In a similar manner the components CO_3, OH, Ca, and Mg of a softened water are scaled along lines *OR-RS-ST-TU* locating point *U* in sector I. Since maximum softening by this process requires the presence of a slight excess of CO_3 and OH ions, this point should fall slightly to the upper right of the origin, *O*, in sector V, and the indications are that the water in this example has been undertreated. Corrective treatment would require both Na_2CO_3 and CaO in amounts not less than indicated by *UW* and *WO* respectively, or Na_2CO_3 and NaOH in amounts not less than *UV* and *VO* respectively.

It will be noted that the plotted point of an untreated water falling directly upon the Mg axis must satisfy the conditions $Ca = CO_2 + 2HCO_3$ and that it will fall in sectors I or II depending upon whether Ca is greater or less than $CO_2 + 2HCO_3$. If the point falls in sector I, the soda ash requirement will be greater than the lime requirement. In sector II the reverse will be true. If, however, the end-point falls in sector III the water contains only carbonate or temporary hardness, and its lime requirement will be equal to the vertical distance to the CO_3 axis, that is, *D* in the figure.

Especially in the field of boiler feed water conditioning this method of graphing the day-to-day treatment operations should prove to be of considerable value. Arbatsky's original papers should be consulted for additional uses of the method.

Hill Trilinear Method

Recently Hill (5) described a method of graphing the mineral character of waters encountered in irrigation practice. In this method, waters are classified into several primary types based upon arbitrary balances between certain cation and anion groups, somewhat as suggested by Palmer, and into subtypes dependent upon the proportionate concentrations of specific ions within the cation and anion totals. For this purpose a special form of

plotting chart, consisting of four equilateral triangles suitably lettered and arranged about a common apex, is used. By plotting trilinearly the percentage equivalent concentrations of the three cation groups and the three anion groups in the two outer triangles respectively, it becomes possible by projection to locate the position of a third point within the two inner triangles which completes the classification.

In the Hill method, illustrated in Fig. 4, the character properties introduced by Palmer—primary salinity, primary alkalinity, secondary salinity and secondary alkalinity—are retained and designated as Groups Z_1, Z_2, Z_3, and Z_4 respectively, with the exception that, in the Z-group formulations, the sulfate is removed from the chloride ion group and included, instead, in the carbonate ion group. Hill terms the four Z groups, in order, as common salt, alkali, bittern, and hardness groups respectively.

In Fig. 4, point A in the cation triangle at the left represents a water in the plotting of which the perpendicular distance to any side is proportional to the equivalent concentration of the cation indicated. Similarly, in the anion triangle to the right, the anion groups are plotted to locate the anion point A. From the two points thus obtained, parallels to the top or bottom sides of the figure are drawn to a point of intersection, which in the example falls in the upper right of the Z_3 triangle. A study of the figure will show that each of the perpendiculars from this third point, as drawn, is proportional to the percentage of the particular Z group indicated. This is explained by the fact that the value of Z_1 must equal either $(Na + K)$ or $(Cl + NO_3)$ and must fall, therefore, on the line of projection from the cation triangle. Similarly, the value of Z_4 must equal either $100 - (Cl + NO_3)$ or $100 - (Na + K)$ and must fall on the line of projection from the anion triangle. The point of intersection of the projected parallels, therefore, determines the values of Z_1 and Z_4, and these, in turn, determine the value of Z_3.

It should be noted that in obtaining the Z-group values by this method, independent values of Ca and Mg as well as of SO_4 and HCO_3 are used. This would be unnecessary if the object of the method were to determine merely the Z-group values, because the Z groups, as defined, involve only the relative magnitudes of certain ion-group totals. One object of the Hill trilinear method, however, is to obtain a more comprehensive classification, i.e., one in which subtypes are indicated. This is accomplished by adding to the Z-group classification terms to indicate the dominance of individual cations and anions. For this purpose each of the four triangles is subdivided into four smaller triangles, and, by lettering or numbering each of these smaller triangles in accordance with a prescribed pattern, the location of the three points which define a given water can be formulated. Thus, in the example shown, water A is classed as *b*III*d*. The primary

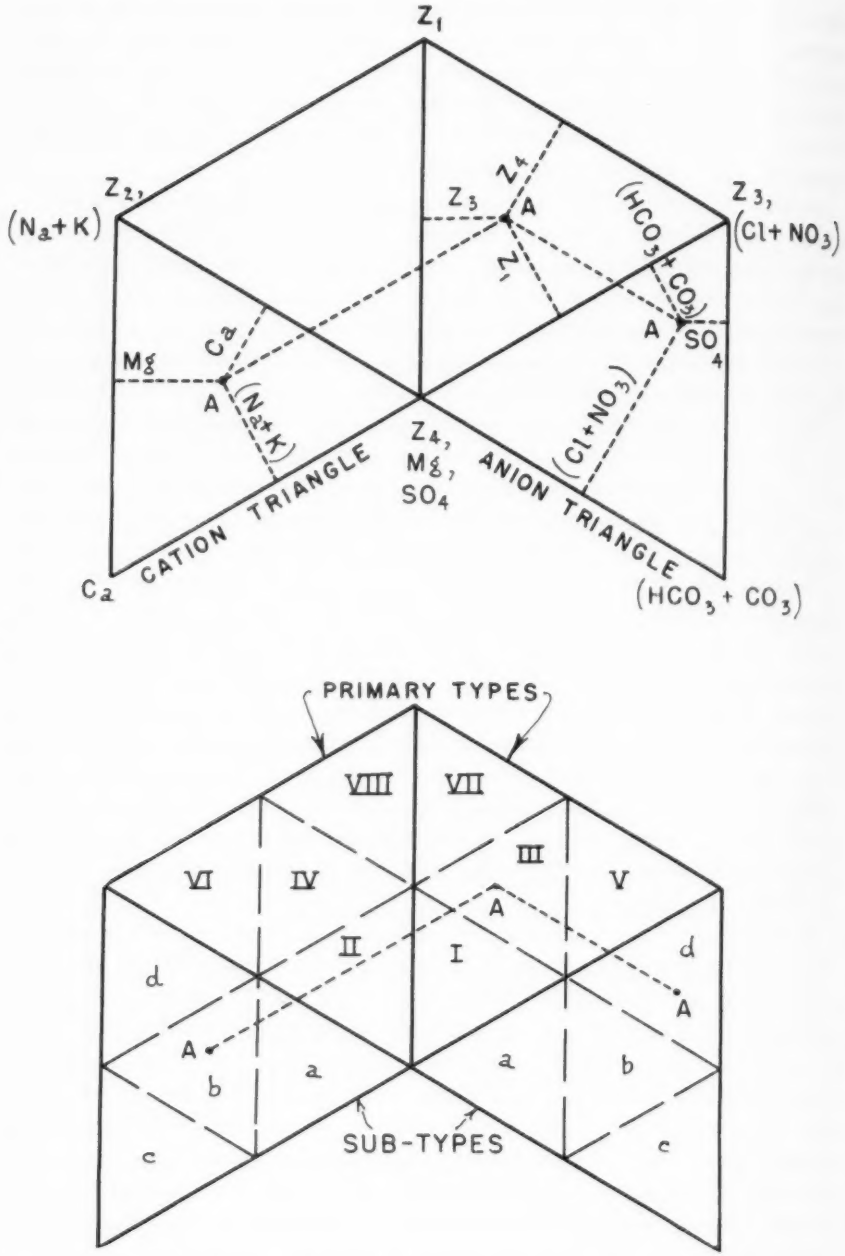


FIG. 4. (*Top*) Hill Trilinear Method of Plotting an Irrigation Water, to obtain percentage of each *Z* group present (*each triangle has three percentage scales—not shown—, each perpendicular to a side*); (*Bottom*) Same Diagram, with classification areas included (water *A* would be classed as *b*III*d*)

classification is indicated by the Roman numeral. An odd numeral indicates the presence of salts of the Z_3 group. The particular numeral, III, representing the inner smaller triangle of the Z_3 triangle, indicates that none of the individual Z groups exceeds 50 per cent of the total. The prefix, *b*, representing the center subdivision of the cation triangle, indicates that none of the three cations exceeds 50 per cent of the total cation concentration. The suffix, *d*, representing the upper division of the anion triangle, indicates that the ($Cl + NO_3$) group is in excess of 50 per cent of the total anion concentration. The complete classification *b*III*d* would therefore indicate a water of the bittern type (but not dominantly so) in which, of the ion groups, only the chloride is dominant.

It should be noted that in this method, as in the modifications to be described, the point locations indicate water types or classes based upon ratios of constituent parts. If total mineralization or absolute concentrations are desired they must be indicated by additional means. For this purpose Hill uses circles of varying diameter centered over the indicated points, making the circle areas proportional to total concentrations.

Hill's paper gives interesting applications of the method. One in particular shows the changes in the mineral character of Rio Grande River water at several stations along its course, and another describes the application of the method in proving that a water which is believed to be a mixture of two or more waters is in fact such a mixture.

A criticism by Scofield (5) carries the implication that graphical methods such as these may be of restricted application in irrigation practice because they omit from consideration certain trace constituents—as, for example, boron in irrigation waters—which may impart to them their most important characteristics. To the authors, however, it seems that, even in these waters, the mineral classification is desirable. It is always possible to indicate the amounts of trace elements or other minor constituents by the use of additional symbols.

Adaptation of Hill Method to Palmer Groupings

In attempting to adapt the Hill method to the Palmer groupings (wherein the sulfate ion is grouped with the chloride and nitrate rather than with the carbonates), it was found necessary to alter the outward shape of the diagram. This new form, illustrated in Fig. 5, permits the use of standard triangular co-ordinate graph paper as, for example, K. and E. No. 358-32. The essential features of the Hill method of plotting and of classification into types and subtypes is retained. It differs, necessarily, only in the arrangement of scales and in terminology. In this modification there are two primary classifications: Palmer Class 1, (middle triangle) and Palmer Class 3 (top triangle). Each of the larger primary triangles is subdivided

into smaller secondary triangular fields (*a*, *b*, *c*, *d*) for the purpose of indicating the dominance of a particular constituent or property. The pattern employed in lettering these fields has been selected to conform in alphabetical sequence with the order commonly used in reporting the constituents of a water analysis: *a* for sodium, chloride and primary salinity; *b* for magnesium, sulfate and either primary alkalinity or secondary salinity;

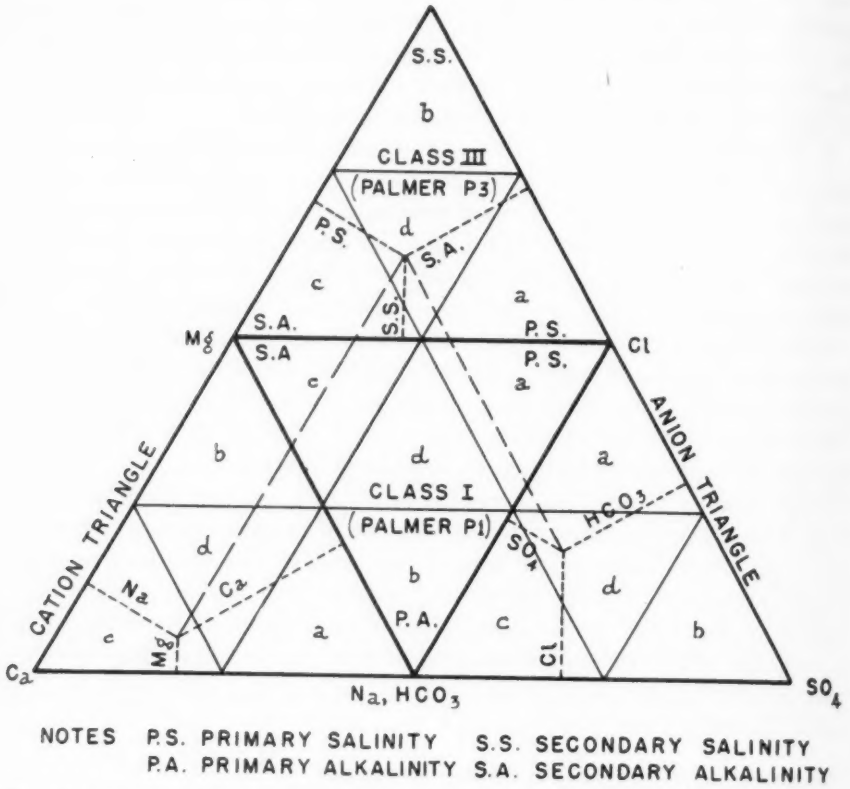


FIG. 5. Authors' Adaptation of Hill Trilinear Method to Palmer Geochemical Groupings—plotted water would be classed as *P3cdd* (*percentage scales not shown*)

c for calcium, carbonates, and secondary alkalinity. The smaller central triangular fields are each lettered *d* to indicate that, within these areas, none of the three variables is dominant, i.e. greater than 50 per cent of the total.

The example plotted in Fig. 5 shows a water of Class *P3*, type *d*, subtype *cd*. The complete classification would be written *P3dcd*, indicating a water which possesses the property of secondary salinity but in which none of the

geochemical properties exceeds 50 per cent, and in which, among the ions, only calcium is dominant. In the complete classification, the sequence and the significance of each symbol should be easily remembered for the reasons which have been noted.

Authors' Single-Point Method

Figures 6 and 7 illustrate a method of graphing and water-typing which, though less comprehensive than the "three-point" trilinear methods already described, appears to offer compensating advantages in simplicity and practicability. The method employs the simpler Cartesian co-ordinates and is based upon the original Palmer ion groupings in which there are only two independent variables, i.e. percentage of alkali cations plotted as ordinate and percentage of non-carbonate anions plotted as abscissa. The location of a plotted point within one of eight triangular areas characterizes the water as belonging to one of two primary types each with four subtypes.

The plotting diagram, shown in Fig. 6, is a square, ruled with one hundred percentage units per side. The square is divided into two primary triangular areas by a diagonal connecting the lower left and the upper right corners. Each of these primary areas is subdivided into four secondary triangular areas of equal size by lines connecting the midpoints of their three sides. The secondary areas of the upper primary field above the diagonal are lettered *A1*, *A2*, *A3*, and *AA* in accordance with a definite pattern; similarly, the secondary areas of the lower primary field are lettered *B1*, *B2*, *B3* and *BB*.

In the use of the diagram, if the percentage of alkali is greater than the percentage of non-carbonate anion, the plotted point will fall in the upper primary field; if the reverse is true, it will fall in the lower primary field. Since these percentage relationships are the basis of the Palmer classifications into Class 1 and Class 3 respectively; point locations in the two primary fields serve to identify waters of these two classes. Also, since, by definition, two of the three percentage values, which express the character formula of the water, are equal to the perpendicular distances from the plotted point to the two sides of the primary right triangle, it follows that the third value will be proportional to the perpendicular distance to the hypotenuse. Thus, with the incorporation of suitable scales, the character formula can be read directly from the diagram. For this purpose the inner scales have been provided.

The use of the terms "primary" and "secondary" as proposed by Palmer in designating the mineral properties of water has not found wide acceptance among water technologists. In the method of classification proposed by the authors a somewhat more self-indicating terminology has been

TABLE 1

Classification of 68 Large U.S. Water Supplies Shown Graphically in Figure 7

NO.	SUPPLY	CLASSIFICATION	NO.	SUPPLY	CLASSIFICATION
3	Birmingham, Ala.	B2-2.2	330r	St. Louis, Mo.	B1-5.0
18	Phoenix, Ariz.	B1-5.8	330s	St. Louis, Mo.	B2-3.3
19	Tucson, Ariz.	B1-7.7	337	Butte, Mont.	A1-2.3
39	Los Angeles, Calif.	A2-5.6	346	Omaha, Neb.	B2-7.9
40	Oakland, Calif.	B1-1.2	350	Reno, Nev.	B1-1.1
48	San Francisco, Calif.	B1-2.3	379	Newark, N.J.	B2-0.7
56	Denver, Colo.	B2-3.5	392	Albuquerque, N.M.	A3-7.3
66	Hartford, Conn.	B1-0.5	401	Buffalo, N.Y.	B1-2.6
84	Washington, D.C.	B1-2.2	415a	New York, N.Y. (Catskill)	B2-0.5
85r	Daytona Beach, Fla.	B1-10			
85s	Daytona Beach, Fla.	B3-5.4	415b	New York, N.Y. (Croton)	B1-1.2
87	Jacksonville, Fla.	B2-6.3			
90r	Miami, Fla.	B1-6.3	445	Winston-Salem, N.C.	B1-0.7
90s	Miami, Fla.	BB-2.7	456	Cincinnati, Ohio	BB-2.9
101	Atlanta, Ga.	B2-0.4	457	Cleveland, Ohio	B1-2.7
114	Boise, Idaho	A1-1.6	459s	Columbus, Ohio	B3-3.7
125	Chicago, Ill.	B1-2.8	490s	Oklahoma City, Okla.	B3-9.0
145r	Springfield, Ill.	B1-5.7	503	Portland, Ore.	A1-0.3
145s	Springfield, Ill.	B2-2.8	532	Philadelphia, Pa.	B1-1.8
155	Indianapolis, Ind.	B1-6.0	533	Pittsburgh, Pa.	B1-2.4
168s	Cedar Rapids, Iowa	BB-2.1	552	Providence, R.I.	BB-0.6
172	Des Moines, Iowa	B1-7.0	558	Charleston, S.C.	A3-1.1
181	Sioux City, Iowa	B2-13	576	Knoxville, Tenn.	B2-2.5
190	Kansas City, Kan.	B2-6.5	577	Memphis, Tenn.	A1-1.5
191r	Lawrence, Kan.	B1-7.2	589	Houston, Tex.	AA-6.5
191s	Lawrence, Kan.	B2-3.4	603	Salt Lake City, Utah	B1-1.6
197r	Topeka, Kan.	B1-7.2	618	Richmond, Va.	B1-1.3
197s	Topeka, Kan.	BB-3.5	630	Seattle, Wash.	A1-0.6
198	Wichita, Kan.	B3-24	631	Spokane, Wash.	B1-3.3
214r	New Orleans, La.	B1-3.6	657	Milwaukee, Wis.	B1-2.8
214s	New Orleans, La.	B2-2.4	667	Cheyenne, Wyo.	A1-1.8
226	Baltimore, Md.	B1-1.2	—	Metropolitan Water Dist.	
236	Boston, Mass.	B2-0.6		(S. Calif.):	
277	Detroit, Mich.	B1-2.1		Raw	B2-13.0
300	Minneapolis, Minn.	B1-3.6		Lime Treated	B2-12.0
325	Kansas City, Mo.	B2-7.0		Zeolite Softened	B3-12.0

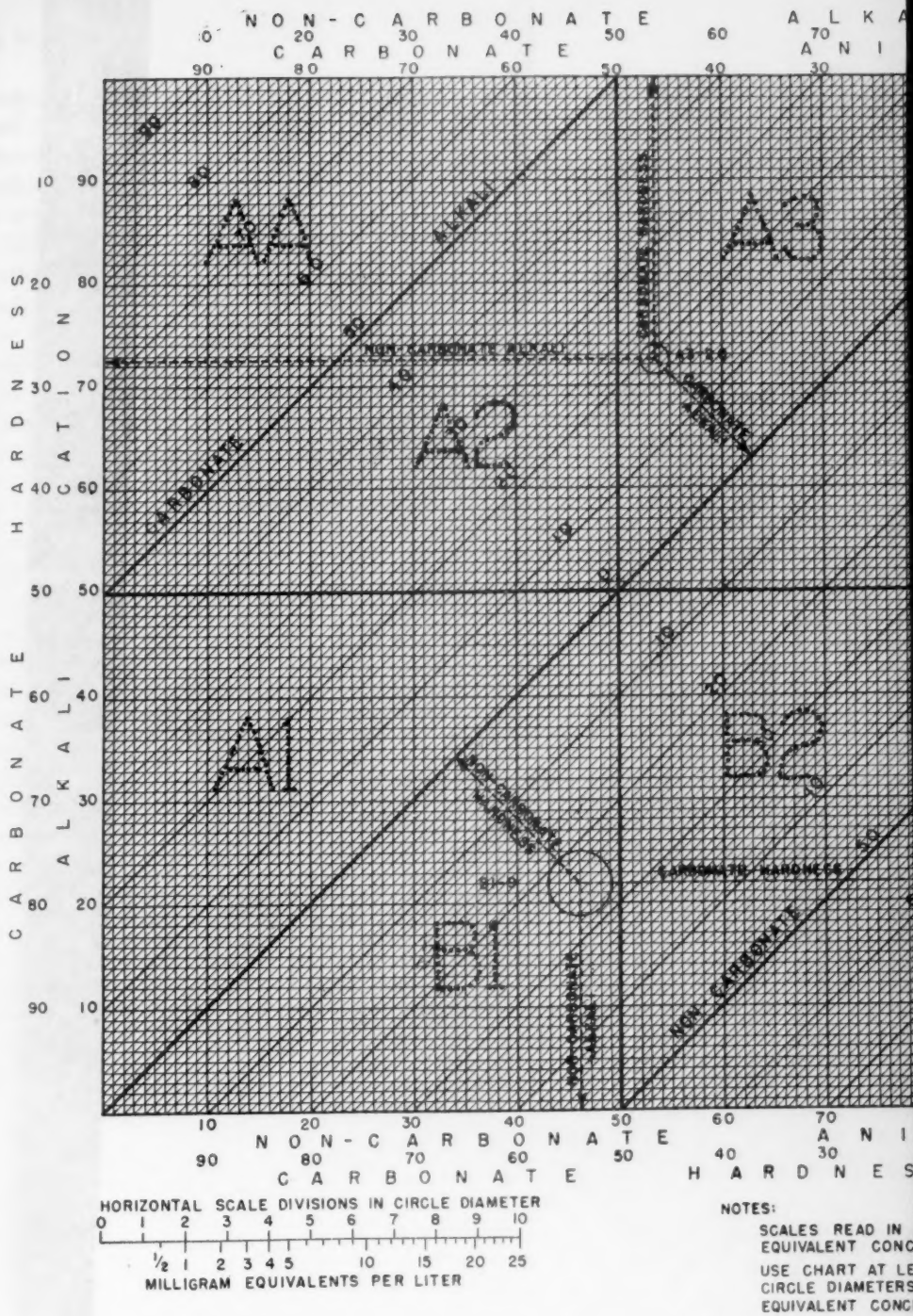
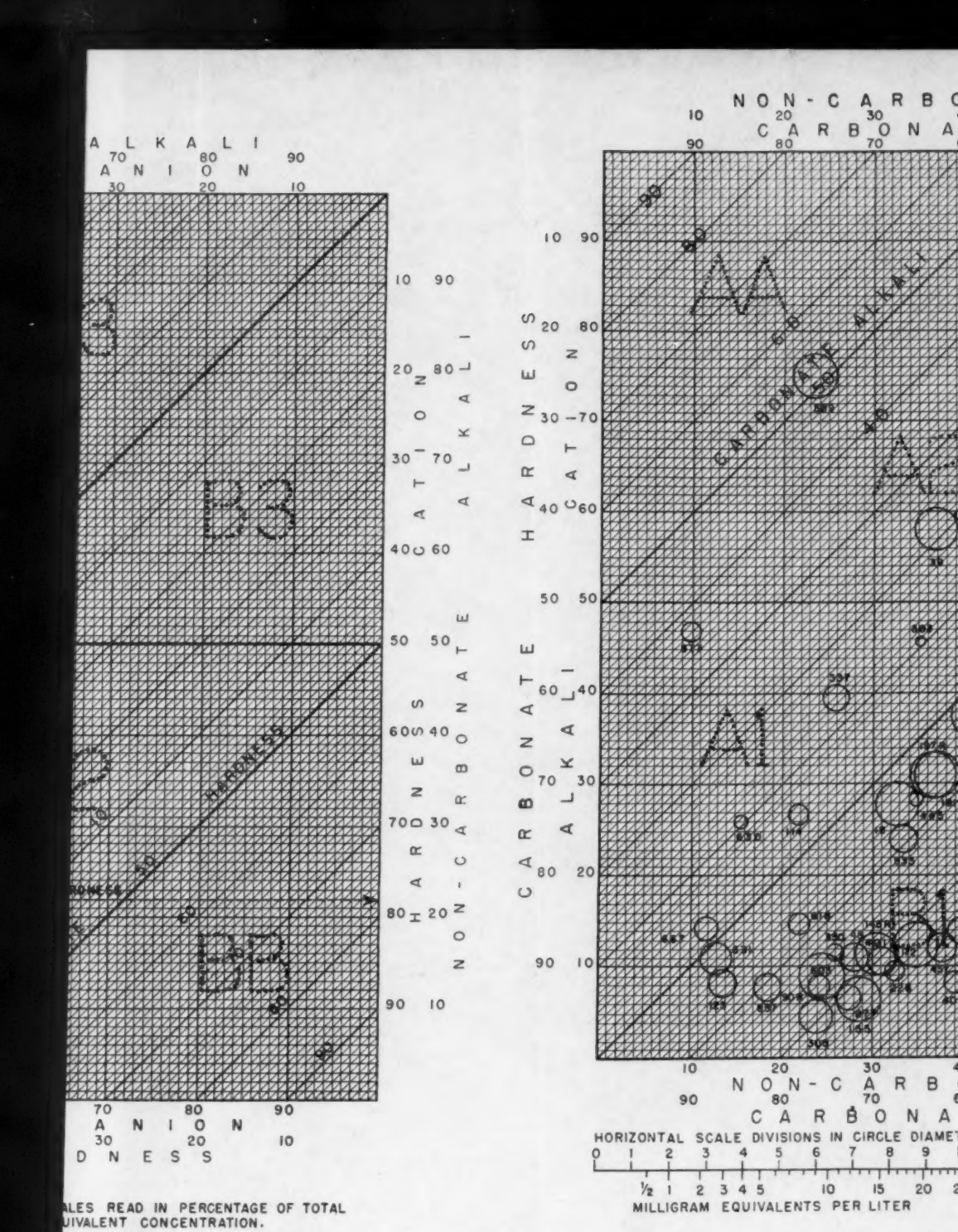


FIG. 6. Authors' Single-Point Method of Graphing and Classifying Waters for I



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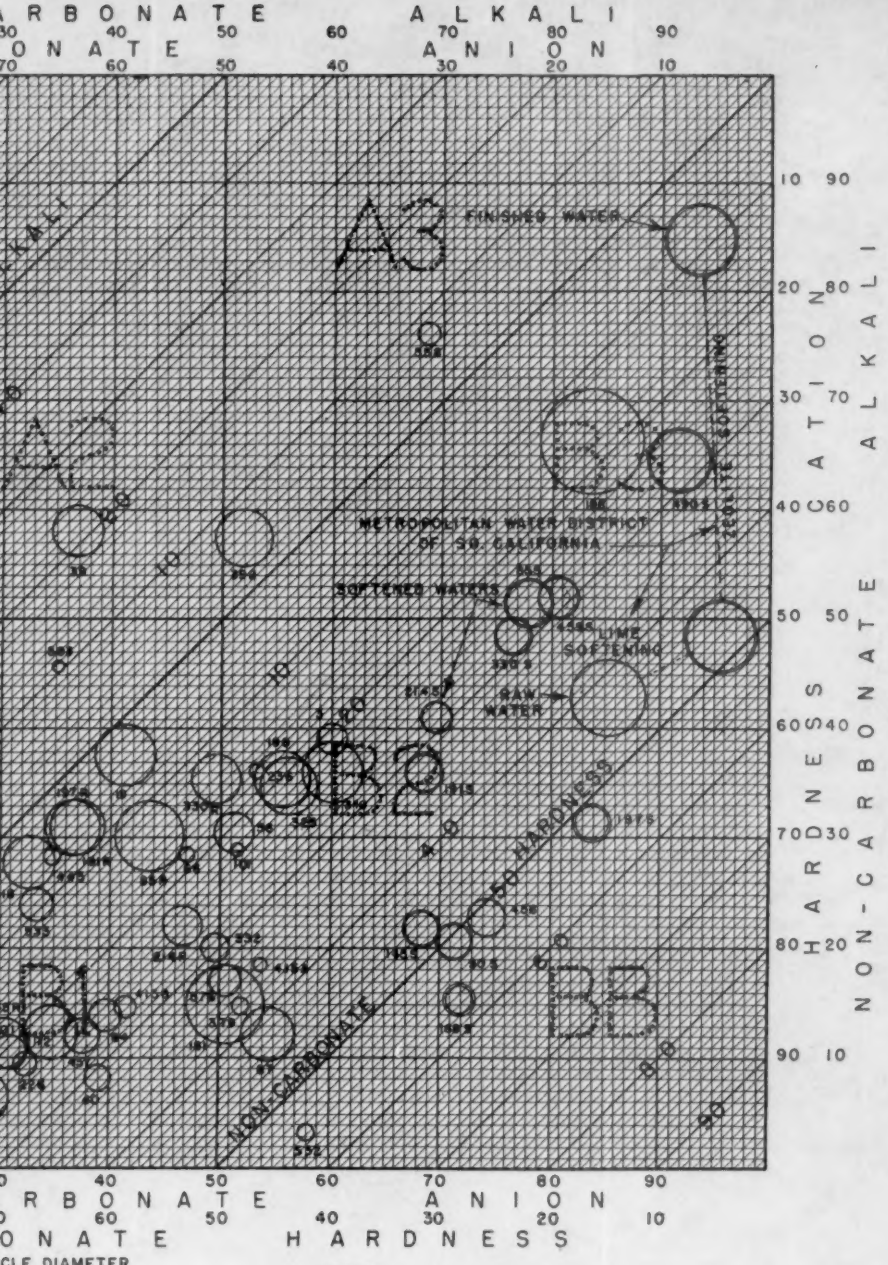
g Waters for Mineral Content

FIG. 7. Example of Use of the Single-Point Diagram
mineral analyses of 68 municipal water supplies
Supply Pap



NOTES:

SCALES READ IN PERCENTAGE OF TOTAL EQUIVALENT CONCENTRATION.

USE CHART AT LEFT FOR CONVERTING CIRCLE DIAMETERS INTO TOTAL EQUIVALENT CONCENTRATION.

FOR DATA ON SUPPLIES AND THEIR CLASSIFICATION SEE TABLE 1.

t Diagram, intended to show its value in plotting large number of analyses; showing supplies from throughout U.S.—analytical data are from U.S. Geological Water upply Paper 658 unless otherwise indicated

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adopted. The four properties are named non-carbonate alkali, carbonate alkali, non-carbonate hardness, and carbonate hardness.

Since, for most purposes, it is desirable to know both relative and absolute concentrations, the scheme of representing each water by a circle, the area of which is proportional to total concentration of salts—as used by Hill in the trilinear method—is retained, and a convenient scale for making conversions of circle diameters into milliequivalents per liter, or the reverse, has been included as a part of the diagram.

As in the trilinear method, the subdivision of the primary areas into secondary areas serves the purpose of subclassification. Point locations within a particular secondary area indicate that the value of a certain group property or a group constituent is either greater or less than 50 per cent. Reference to the diagram will show that classifications *A1* and *B1* indicate waters in which the property of carbonate hardness is dominant; that is, this property exceeds 50 per cent in the character formula. These classifications differ, as do all *A* and *B* waters, in that the former are alkali carbonate and the latter non-carbonate hardness waters. Waters in which these distinguishing properties are dominant will fall within the *AA* or *BB* sectors respectively. The *A3* and *B3* classifications indicate waters of relatively high salinity, that is, waters in which the property of non-carbonate alkali is dominant. The classifications *A2* and *B2* indicate waters in which none of the three properties is dominant. The ionic group relationships, characteristic of each sector, are readily apparent. Thus, the entire upper half of the diagram, sectors *AA*, *A2*, *A3* and *B3* represent types of waters in which the alkali ion group is dominant. In the lower half, the hardness ion group is dominant.

In addition to simplicity and practicability, an advantage of the single-point method, as described, is that, by its use, a large number of analyses can be plotted upon a single diagram. An example is shown in Fig. 7. On this diagram there are plotted analyses of 68 of the larger and more important municipal water supplies throughout the country. An examination of this diagram will reveal interesting facts pertaining to these supplies which, were the data presented in the usual tabular form, might readily pass unnoticed.

A breakdown of the 56 *raw* waters plotted in Fig. 7 shows that 82 per cent fall into the *B* sectors and are therefore classed as non-carbonate hardness waters. Of the 56 waters nearly two-thirds, 63 per cent, fall within the *A1-B1* quadrant indicating carbonate hardness as the dominant property; an additional 25 per cent fall within the *A2* and *B2* sectors, indicating no dominant properties; and the remaining 12 per cent are about equally distributed among the *A3-B3* quadrant and the *AA-BB* sectors.

The center of gravity of the plotted points, together with the median circle area, establishes what might be called a typical raw water. It is interesting to note that the largest body of fresh water in the world, the Great Lakes, furnishes the supplies most resembling this typical water.

The effect of water-softening by the lime-soda process is a shifting from the raw-water position to the right and slightly upward. Softening by the zeolite process causes a shifting from the raw-water position directly upward.

Problem of Mixtures

Frequently in hydrological studies, mineral water analyses are utilized in tracing the movements of ground waters, sometimes with a view to the confirmation of apparent mixtures. For this purpose, samples of water from selected locations are analyzed chemically, and consideration is given to the relative concentrations of certain ionic constituents. Since both the three-point and single-point methods of graphing are based upon the plotting of ratios, these diagrams can be used to advantage in the solution of problems of this character. Their value arises from the fact that the plotted point of any mixture of two waters must fall along a line which connects the plotted positions of the two waters composing the mixture. From this it must follow that the plotted position of a mixture of three waters must fall within the triangle formed by the plotted positions of the three waters composing the mixture. Also, since the total concentration Z of a true mixture can be neither lower than the lowest nor higher than the highest concentrations of the individual samples composing the mixture, the circle area of a true mixture must conform therewith. Accordingly, a mere examination of the plotted values of an apparent mixture and of its component parts will furnish a fair indication as to whether or not such mixture is a true, or quantitative, mixture.

Further confirmation of the presence of a quantitative mixture is readily obtained by two methods, each of which is applicable to the simpler single-point diagram. One of these is a completely graphical method adapted from the trilinear plotting method of Hill (5), and the other, a semi-graphical method involving a simple computation with readings taken from the graph. The following descriptions of these two methods refer to the respective plotted diagrams in Fig. 8, in which, for the purpose of clarity, the scale divisions have been omitted. In the upper left, K is an apparent mixture of waters A, B and C, each plotted in the usual manner. Directly below, the points K', A', B' and C' are plotted in the same manner, except that, in this series, the percentage values of either calcium or magnesium are plotted as ordinates against the a_1 values. The two triangles are

completed by drawing the lines connecting the outer points of each series of values. Intercepts a, b, c, and a', b', c' are obtained by projecting lines from each apex through K and K' respectively. If K is a quantitative mixture as presumed, the corresponding intercepts must fall on the same

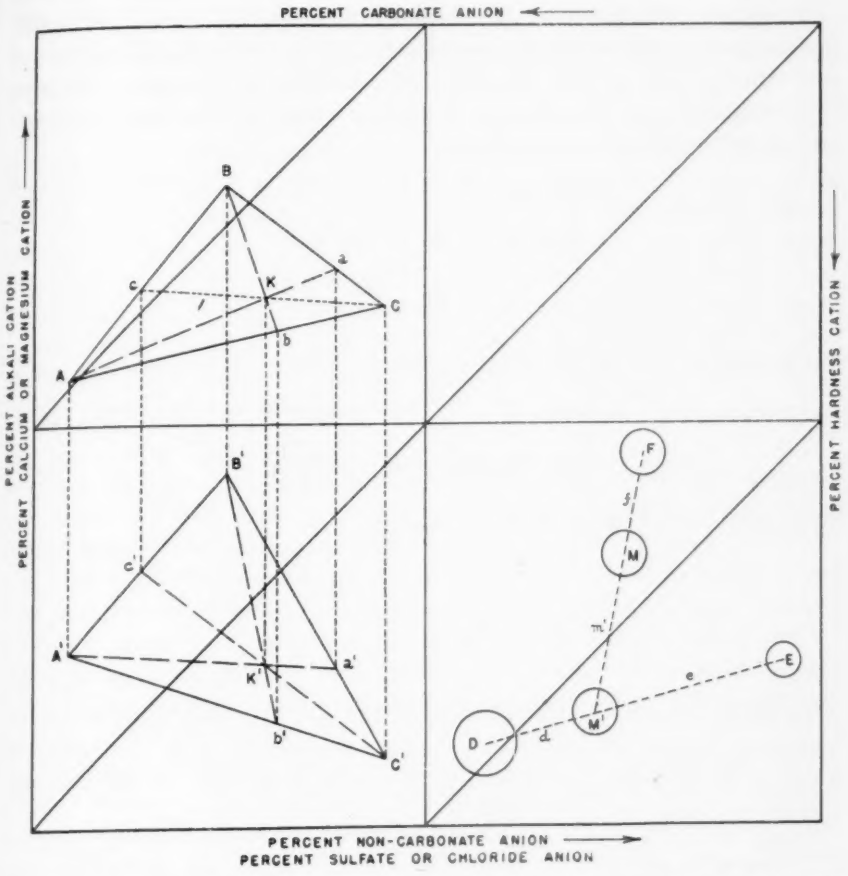

FIG. 8. Use of Single-Point Diagram (*scale divisions omitted*), to confirm an apparent mixture of three component waters—*Left*, Graphical Method; *Right*, Graphical-Algebraic Method

vertical lines. In the absence of independent values of calcium and magnesium, or if additional confirmation is desired, the same method of plotting can be used, substituting the value of either chloride or sulfate for the value of a_1 and plotting each against c_1. In this case the intercepts should fall on the same horizontal lines.

In the foregoing method the total concentration of the mixture Σ_m is not established; that is, neither dilution of the mixture by rain water nor concentration by evaporation would be indicated. The alternate method, illustrated on the right of Fig. 8, appears to offer a simpler solution to the problem of mixtures. In this method, M is an apparent mixture of waters D, E, and F. The intercept M', obtained by projecting the line FM to DE, represents a hypothetical mixture of D and E, in which the proportions of each are the same as are present in M. Letting the symbol Σ represent concentrations and V, volumes, by taking moments about the points D and E, two equations are obtained:

$$\Sigma_E \cdot V_E(e + d) = \Sigma_{M'} \cdot V_{M'} \cdot d$$

$$\Sigma_D \cdot V_D(e + d) = \Sigma_{M'} \cdot V_{M'} \cdot e$$

or

$$V_E = \frac{\Sigma_D \cdot V_D \cdot d}{\Sigma_E \cdot e}$$

If the volume of water D entering into the mixture M' be taken as unity, the volume of E becomes $\frac{\Sigma_D}{\Sigma} \cdot \frac{d}{e}$. The weight of salt contributed by D equals Σ_D and the weight contributed by E equals $\left[\frac{\Sigma_D}{\Sigma_E} \cdot \frac{d}{e}\right] \Sigma_E = \frac{\Sigma_D \cdot d}{e}$. Thus, the concentration of the mixture is

$$\Sigma_{M'} = \frac{\Sigma_D + \Sigma_D \cdot \frac{d}{e}}{1 + \frac{\Sigma_D}{\Sigma_E} \cdot \frac{d}{e}} \quad \text{or} \quad \frac{\Sigma_D \left(1 + \frac{d}{e}\right)}{1 + \frac{\Sigma_D}{\Sigma_E} \cdot \frac{d}{e}}$$

In the use of this equation to solve for the concentration value of M', the values of d and e are obtained by scaling the graph. The concentration value of M can then be obtained by the same procedure. In the example plotted the solution is as follows:

From chemical analysis:

Water	D	E	F	M
Σ (mE/l.)	10.0	3.00	5.00	5.15
c_1	10.0	20.00	47.50	30.00
a_1	57.5	95.00	77.50	74.50

By scaling $d = 37$, $e = 62$, $f = 33$, $m' = 50.5$.

$$\Sigma_{M'} = \frac{10\left(1 + \frac{37}{6.2}\right)}{1 + \frac{10}{3} \cdot \frac{37}{62}} = 5.35\text{mE/l.}$$

and

$$\Sigma_M = \frac{5.35\left(1 + \frac{50.5}{33.}\right)}{1 + \frac{5.35}{5.} \cdot \frac{50.5}{33.}} = 5.15\text{mE/l.}$$

The calculated value of Σ_M agrees with the analytical value and therefore affirms the presence of a true mixture.

Either of the methods described can be used to confirm apparent mixtures of two or more components, provided an analysis of each is available. Under the conditions of natural flow either underground or in surface streams, however, water mixtures in most instances must be regarded as extremely complex and probably not subject to a strictly quantitative treatment. The authors are inclined to agree with Collins (5) that "an actual irrigated plot of 15,000 acres does not act like a glass vessel or like a bed of pure silica sand." It is believed, however, that the methods described can be used to advantage in the solution of many problems involving the movements of subterranean waters.

Summary and Conclusions

It is believed that in the preparation and publication of results of water supply surveys and other hydrological investigations, the methods of graphing and water-typing which have been described should find an enlarging field of usefulness. With the exception of the double-bar method, the methods described are of recent origin, and it is too early to predict which method will prove to be of most value. The authors believe that there are uses for each method and that selection of a method for a particular purpose will depend upon the nature of the problem.

The double-bar graphs are more tedious to prepare but are very useful where it is desired to present a visualization of the data for the benefit of the general reader. In the fields of boiler feed water conditioning and water softening, uses may be found for vector diagrams as developed by Arbatsky. The trilinear and rectilinear methods of co-ordinate plotting should be found most useful in irrigation and water survey investigations, particularly where it is necessary to compare the results of large numbers of analyses. If future experience should indicate that it is desirable to classify waters into types that can be readily identified by symbols, the point method of graphing would seem to offer the most suitable basis for such classification.

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A Bacteriologist Looks at Chlorine

By Stella M. Costigan

THE growing importance of chlorine and its compounds in sanitation has led to extensive research into its capabilities as a germicide. In view of the current discussions on the revision of drinking water standards and of the recent remarkable advances in water chlorination, it appears timely to review the bactericidal status of this increasingly useful servant. Not only in water purification, but in other sanitation fields, is chlorine becoming indispensable for the protection of public health. This is largely because it is a powerful germicide, non-poisonous to man when used in the concentrations required to destroy most pathogenic organisms ordinarily encountered in the control of water, milk and other foods for the public.

The germicidal efficiencies of chlorine and its compounds have long been known. As early as 1800 (1) it was used as a disinfectant. Its recorded use in water purification dates back to 1850 in Europe (2) and to 1896 in the United States. In 1906 (3) chlorine, in the form of chlorinated lime, came into practical use for water purification in the United States and in 1910 chlorine gas was first used for this purpose. Eight years later (4) over 2,500 municipal plants in the United States were using chlorine; and by 1925 over 75 per cent of the municipal drinking water supplies in North America were so treated. At the present time it is estimated that 85 per cent of the public water supplies are chlorinated (5).

Other germicides will also satisfactorily destroy microscopic life but chlorine's unique combination of availability, ease of handling, dispensing simplicity, freedom from poisonous residuals, and its specific high toxicity for most water-borne disease organisms makes it today's most important chemical sanitation agent.

A paper presented on November 7, 1941, at the Four States Section Meeting, Baltimore, by Stella M. Costigan, Bacteriologist, Research & Development Dept., Pennsylvania Salt Mfg. Co., Philadelphia.

Limitations of Chlorine

The demonstrated effectiveness of chlorine should not, however, engender a false sense of security for, like all chemical disinfectants, it is selective in its application and has its limitations. For example, the turbidity limits of the Federal drinking water standards (6) are bacteriologically well justified and might well be made more rigid. Chlorine is effective only on naked organisms and, in the concentrations normally employed in water sanitation, cannot be expected to penetrate into clumps of solid matter any more than beneficial sunshine can be expected to penetrate into the recesses and closets of a residence. It is pertinent, also, to remember that chlorine, combined as a hypochlorite, is a classical example of the selectivity of chemical disinfectants. The literature is in agreement that *Mycobacterium tuberculosis* is not affected by strongly alkaline hypochlorites above room temperatures and that the practice of using alkaline sodium hypochlorite to isolate the organism is correct. Fortunately, tuberculosis is not a water-borne disease, and this limitation has no significance in water chlorination other than its timely reminder that chlorine is not a universal bactericide.

The ease of using chlorine and its general success have unfortunately at times caused carelessness and overconfidence. This is being recognized particularly since the growing acceptance of the more effective superchlorination methods of water disinfection in which chlorine is made more effective by insuring the destruction of inhibiting nitrogen compounds. In discussing the proposed revision of the Federal standard, Cox (7) observes "... that in the past undue confidence has been placed in the effectiveness of some arbitrary concentration of residual chlorine, such as the range of 0.1 to 0.2 ppm. after a 10-minute reaction period, without due weight being given to the influence of oxidation potential, pH, organic content, temperature, reaction time, and other variables." The wisdom of this observation is apparent.

Reasons for Chlorination

Water is a food but unlike many foods is not disinfected by cooking. It may be considered a raw food which comes in contact with a number of materials that may contaminate it to make it unfit for human consumption (4). The literature is abundant with references which indicate that certain of the intestinal diseases are water-borne. Water is treated to destroy the disease-producing organisms that may have contaminated it.

Without doubt chlorination of water has brought about a tremendous decrease in deaths from typhoid fever. In 1900 the typhoid death rate was 35.8 per 100,000 population as compared with less than 2 today (8). The outbreaks of typhoid fever reported in the last decade can be explained

by failure to apply adequate precautions either in the protection of supplies or in the treatment of the water (9). All water-borne outbreaks, where complete information was available, were transmitted by water known to be subject to bacterial pollution. Wolman and Gorman (10) also report that more than 75 per cent of the water-borne illness reported in the United States in the period 1920 to 1929 was due primarily not to pollution of the raw water at its source, but to defects in the system for collection, treatment, storage, or distribution. The outbreak of *Brucella melitensis* infection at Michigan (11) certainly falls in this group as well as the paratyphoid infection reported by Hippe (12) and the small New Hampshire dysentery outbreak (13).

Conscientious water purification men aim not only to make water less dangerous, but also to make it safe. As stated by Beard (14) we are concerned with the organisms which survive treatment rather than the numbers that die. Inadequate treatment, carelessless, and ignorance are not valid explanations for a water-borne outbreak of intestinal disorders. There can be no compromise on this point. Indeed, experience has shown that, correctly to be called "safe," a public water supply must also be above reproach aesthetically. Otherwise the public resorts to more palatable, but less closely supervised, supplies. Today, the goal of water chlorination extends far beyond the original bacterial consideration into chemical effects which, by more complete oxidation of objectionable organic matter, aid in the production of a pleasing water.

Safety of Chlorinated Water

As most of us are aware in studying the bacteriological conditions of water, the presence or absence of lactose fermenters of the coliform group is the criterion of safe or unsafe water. At the present time, there is no basis for any attempt to evaluate a drinking water by distinguishing between the fecal or non-fecal types (6). In studying chlorinated supplies, conditions which appear to throw the bacteriological studies out of line are present. Streeter (15) believes that chlorination may tend to modify or perhaps attenuate the cultural characteristics of some bacteria of the coliform group to such an extent that they may fail to respond to the routine tests for confirmed coliform organisms. He suggests improving the technique and clarifying the interpretation of coliform tests in treated water, and particularly in chlorinated waters, with a view toward detecting significant changes in the bacterial flora.

Levine and co-workers (16), in studying members of the *Aerobacter aerogenes* group isolated from a number of chlorinated waters, mostly unfiltered lake supplies, state that the evidence on the whole indicates that the survival of these strains in chlorinated water is probably due to

the presence of clumps of bacteria or protection of the organisms by some constituent of the water, such as suspended solids, rather than to resistance of the individual bacteria to the action of chlorine. This is an important observation. The bacteriological record of poorly filtered or unfiltered chlorinated waters is generally unimpressive. Chlorination will improve the potability of such waters, but it cannot entirely correct filtration deficiencies.

Freidberg (17) also worked with coliform bacteria isolated from chlorinated water and concluded that there was only a slight variation in resistance to chlorine of different strains of *Escherichia coli*, but that other coliform bacteria may be more resistant to chlorination. The work of Tonney, Greer, and Danforth (18) has shown that *Esch. coli* is the most resistant type of bacteria encountered in the intestinal group and is a satisfactory criterion for effective disinfection. Their work has also shown that most strains are readily destroyed by chlorine; the more resistant, however, require higher concentrations.

Bacteriological Significance of Residual Chlorine

What are the factors that influence the efficiency of chlorine to the extent that its effectiveness may be reduced or nullified? Are our chlorine control tests lacking, and, as suggested by Levine (16), do they need revaluating?

Mallman and Carey (19) found that with swimming pool waters the ortho-tolidine test does not closely follow the bacteriological relationship previously reported by Stovall, Nichols, and Vincent. Later Mallman and Ardrey (20) reported that neither the starch-iodide nor the ortho-tolidine test gave accurate indications of relative germicidal activity of various concentrations of chlorine either in the presence or absence of organic matter. They also found little or no correlation of bacteriological activity of chlorine residuals measured by these two methods in the presence of organic matter.

The ortho-tolidine test admittedly is influenced by iron, manganese, and nitrites (6). Johnston (21) also reported that under some conditions algae interfere with both tests. In view of these findings these tests should not be considered bacteriologically infallible even if all of the precautions prescribed by *Standard Methods* have been meticulously observed.

It can be seen that either the starch-iodide or ortho-tolidine test should be used only as a means of control of water chlorination and should not take the place of routine bacteriological examinations. This point cannot be emphasized too strongly. The accepted standards of drinking water quality cannot be met unless the water is examined bacteriologically; and, it is evident that only by such examinations can one be certain that the finished water is safe.

Factors Influencing Chlorine Kill

There are several factors which affect the efficiency of chlorine, whether used for water purification or in some other phase of sanitation. The most important of these are organic matter, hydrogen ion concentration, temperature, chlorine concentration, and turbidity.

Organic Matter

The quantity and type of organic matter in the water to be treated markedly affect the germicidal efficiency of chlorine. Several investigators have studied this effect. Fabian and co-workers (22), Tilley (23), Beard and Kendall (24), and Levine (2, 25) have all found that hypochlorites are readily attacked by organic matter and are rapidly dissipated. Apparently, a complex reaction takes place when chlorine comes in contact with organic matter (26). This is believed to be the reason for the continued germicidal effect of chlorinated water containing organic matter, even after no chlorine residuals can be detected.

Hydrogen Ion Concentration and Alkalinity

The pH of water probably has the greatest influence on activity of chlorine. Johns (27), Mallmann (20), Levine (2, 25), and Costigan (28) have found that hypochlorites with a low pH are quicker acting than those of a high pH. Increased alkalinity causes decreased germicidal activity. This effect has been observed both in the lower concentrations (0.2 to 0.5 ppm. residual chlorine) used in water purification and, also, in the higher concentrations (50 to 200 ppm.) used for utensil disinfection (28, 29).

The studies by Mallmann and Miller (30) of the stability of chlorine in zeolite-softened waters are of interest here as a new approach to the question of effect of alkalinity on chlorine activity. They found that calcium-free swimming pool waters were more difficult to disinfect than waters containing calcium. When calcium hypochlorite was used, the germicidal effect in calcium-free water was greater than when sodium hypochlorite or chlorine gas was used.

Temperature

Unpublished work in the laboratory of the Pennsylvania Salt Mfg. Co. has shown that the germicidal efficiencies of hypochlorites in 2½- and 5-minute periods are not readily influenced by temperature except in the destruction of acid-fast organisms (31). The difference in activity at 2, 20, and 40°C. was negligible with *Staphylococcus aureus* but recognizable with *Eberthella typhosa*. Chloramine activity is more sensitive to temperature changes (2).

Concentration

Obviously concentration is most important and it should be emphasized that the desired kill cannot be expected unless sufficient chlorine concentration is provided. The quantity varies with conditions. Again, bacterial measurements are essential to arriving at the desired concentration. One of the most promising results of break-point chlorination is the biological improvement in water in the distribution system. As previously pointed out in this paper, the author agrees with Cox (7) that "undue confidence" has previously been placed in the presence of some fixed chlorine residual in the water after chlorination. Concentration is certainly important, but, in view of modern chlorination practice, the exact effective concentration more than ever becomes one of individual determination for any given plant. With modern break-point chlorination, considerable variance is found in the finished water chlorine residuals tolerated by the public. For example, the conclusions of Chang and Fair (32) on cysticidal chlorine doses show a 30-minute residual at a pH range of 7.0 to 8.2 to be slightly above 3 ppm. This may be tolerated in some waters and not in others.

Turbidity

Bacteriologists do not consider water chlorination as satisfactory protection when appreciable turbidity is present. This is because chlorine is effective only on naked organisms and can not be expected to penetrate into suspended solid matter with sufficient efficiency to insure the desired bacterial kill for drinking water. It must, therefore, be concluded that chlorination is not a complete substitute for coagulation and filtration efficiencies.

Future Problems of Chlorination

Now that the virus of poliomyelitis has been isolated from sewage (33, 34, 35, 36), its resistance to chlorine assumes more than academic interest. Paul and Trask (33) have stated that the virus has never been isolated from drinking or swimming pool water. Kling (37) has reported isolating it. The studies of Paul and Trask (35) as well as those of Kempf and Soule (34) indicate that chlorine dosages greater than those formerly used in water purification are necessary for destruction of the virus. It is very evident that more work must be done on the resistance of this virus to chlorine and that greater efforts should be made to isolate it from polluted untreated water supplies. Until this is done water will probably remain under suspicion as one of the possible agents of the spread of this disease. There is no epidemiological evidence that water is responsible

and everything that is known about the disease points in the other direction except the fact that it has been declared an intestinal disease and the virus has been found in sewers receiving fecal wastes from places hospitalizing poliomyelitis patients.

The chlorine resistance of the cysts of *Endameba histolytica* must also be considered. Magath (38) cites studies of Wenyon and O'Connor in showing that 100 times the chlorine dosage used in water purification does not destroy the cysts after many hours of exposure. Chang's recent work (39) clearly disproves these conclusions and places the cysticidal chlorine dose well within the limits of modern super-chlorination. For municipal water purification, however, emphasis must be placed on other effective safeguards against the spread of this disease through drinking water. The most important of these are watershed protection, adequate coagulation, good filtration, and protection of the distribution system against pollution through defective plumbing and cross-connections.

Here again chlorination has its limitations. Chang obtained destruction of the cysts by chlorine at various concentrations, increasing and decreasing with increases and decreases in pH values. For example, at pH 8.2 the cysticidal chlorine dose is slightly less than 2 ppm. 2-hour residual, slightly more than 2.5 ppm. 1-hour residual, about 3.2 ppm. 30-minute residual, and slightly more than 6 ppm. 15-minute residual. Where contaminated water supplies are not adequately protected by coagulation and filtration, it is obvious that, except in unusual cases, the water must be heavily super-chlorinated and de-chlorinated to be rendered pleasing to the user. It is also obvious that residual chlorine in the distribution system cannot be expected to destroy the cysts introduced through cross-connections or faulty plumbing. Most observers believe that only fresh and serious pollution of potable water leads to the transmission of this disease. Nevertheless, its limitations have now been fairly well established and its elimination as a water-borne disease now becomes one of the responsibilities of water purification.

In this paper the author has endeavored to review the literature and discuss this problem in the line of her experience with chlorine and its compounds as bactericides. Acknowledgment is made to her technical associate, L. L. Hedgepeth, for assistance in arrangement and in achieving a water works viewpoint interpretation of this material.

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Discussion by *John W. Krasauskas.* * Miss Costigan is to be commended on her paper for the concise manner in which the topic of chlorine and its compounds has been handled. She has presented a very interesting and comprehensive survey of the field.

Purification of water by sedimentation, coagulation and filtration cannot be depended upon entirely to ensure a safe water supply. Filtration removes approximately 98 per cent of the bacteria present in the raw water, but does not restrict the passage of pathogens, with the exception

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of *Endameba histolytica* cysts. Therefore, the bacteria in the 2 per cent passing the filters may contain many pathogens, especially if the bacterial load and draw on the filters are heavy. For this reason some form of disinfection must be supplied. Although bromine is more efficient bacteriologically than chlorine it has many disadvantages precluding its use for water purification. Chlorine is better suited as a bactericidal agent because it is almost as effective as bromine, is readily soluble in water and produces no change in color or increase in corrosiveness.

Theory of Chlorine Disinfection

Before considering chlorine as a bactericide, a résumé of the theory involved may be interesting. The oldest theory, now discarded, assumed that nascent oxygen from the decomposition of hypochlorous acid exerted lethal action. At the present time the generally accepted version is the one of toxicity. Chlorine is thought to react with the cell membrane forming chloro-compounds. These chloro-substances interfere with metabolism and cell division resulting in death of the bacterial organism. Studies on chlorine action by the U.S. Public Health Service actually show disintegration of the bacterial cell when chlorine is added to water. This observation tends to support the toxic theory.

Chlorine may be applied to water in a number of ways: simple chlorination, pre-chlorination, double-chlorination, super-chlorination with dechlorination, break-point chlorination and chloramination, depending upon conditions in the plant. The mere addition of chlorine does not solve completely the problem of disinfection. The chlorine demand of a water must be determined by experiment and sufficient chlorine added to meet this requirement with an excess to provide residual chlorine. Even though a residual is provided, other factors such as, turbidity, pH, temperature and contact period must be considered.

An increase in the turbidity or pH diminishes both the oxidizing and bactericidal power of chlorine. The velocity of disinfection can be markedly increased by lowering the pH to 7.0. A similar decrease in germicidal efficiency occurs when the temperature is depressed to 0°C. The normal process of oxidation is prevented with a resultant increased chlorine demand.

Of exceptional import is the absolute necessity for a proper contact period, varying with the mode of application. Chloramines show a definite lag in the velocity of disinfection from 30 min. to 2 hr. Provision of an adequate contact period yields results as good as, and, in some instances better than, that obtained with chlorine alone. Increasing the chlorine in chloramine improves killing power with a decreased contact period.

Generally speaking, the contact time of chloramines should be approximately twenty times that of chlorine alone.

Other Uses of Chlorine

Elimination of pathogens in water is not the only function of chlorine interesting to the bacteriologist. It is used to combat algae, iron bacteria, and aftergrowths in plant systems.

Tastes and odors due to algae can be corrected by super- or break-point chlorination. Chloramines have been reported of value for controlling algal growth in reservoirs. A residual chlorine of 2 ppm. will eliminate ordinary micro-organisms like *Melosira*, *Anabaena*, *Dinobryon*, etc., but even large doses of either chlorine alone or chloramine have no effect on diatoms. Ornstein, killed algae with 2.5 ppm. of chlorine and 0.18 ppm. copper sulfate where doses of 20 ppm. of chlorine and 100 ppm. of copper sulfate alone had previously failed.

The elimination of iron bacteria with chlorine presents a more complex situation. Iron bacteria are capable of absorbing enormous amounts of chlorine. Straight chlorination may or may not be successful, but chloramines because of their persistent residual throughout the system seem of value.

Regarding aftergrowths, it is often observed in hot weather that the number of bacteria growing on agar plates is greater in chlorinated water than in the untreated water. The first effect of chlorine is a decrease in the total count. The same water in the pipelines a couple of days later will show greatly increased counts. This is due to stimulation of aerobic spore-forming bacilli by the effect of small amounts of chlorine on vegetative cells. These vegetates are not chlorine-resistant like the spore from which they emanate. Spores will resist chlorine doses up to 15 ppm. Chloramine treatment, however, is especially effective against this phenomenon.

Combating Water-Borne Gastro-Enteritis

Of current interest are the studies of *Endameba histolytica* as an increasing source of danger in water supplies and the rôle of *Pseudomonas* in gastro-enteritis epidemics.

Chang in a recent article states that the prevalence of *Endameba histolytica* cysts in the United States is greater than previously believed, 5 to 10 per cent of the population being carriers of these cysts. He advocates superchlorination, but Dr. W. S. Stone of the U.S. Army found, under laboratory conditions, that doses of chlorine killing *Esch. coli* will also destroy cysts. Because the evidence is confusing, filtration which prevents passage of the cysts should be resorted to instead of depending on chlorination.

Blame for gastro-enteritis epidemics has been placed on water supplies. These attacks have been of obscure origin with no evidence which would prove water responsible. Recently, however, the *Pseudomonas* family, of which *P. pyocyaneus* is a representative member, has been proposed as the possible cause of these attacks. *P. pyocyaneus* is a normal inhabitant of human and animal intestinal tracts and also of water and soil. It is a slightly virulent, gram-negative rod, growing luxuriantly on ordinary laboratory media at 37°C. It has been isolated from stools of children showing symptoms of diarrhea. Autopsies performed on children whose death was due to gastro-enteritis showed the presence of these bacteria in the various body organs. This research has thrown a new light on the etiology of these attacks, with the possibility of control through the elimination of *Pseudomonas* from water supplies. It is only slightly more resistant than *Esch. coli*, being killed readily by 0.5 ppm. residual chlorine.

Isolation of an Aerobic Sporulating Lactose-Fermenting Organism From Philadelphia Drinking Water

By George M. Eisenberg

IN THE course of performing routine bacteriological analyses of the water produced at the Roxborough Plant of the Philadelphia water works system, it was observed that the filtered and chlorinated water, when inoculated into primary lactose broth fermentation tubes, produced gas which could not be demonstrated as being caused by members of the coliform group. The presence of non-coliform lactose-fermenting organisms in Philadelphia drinking water has been reported previously by Schaut (1, 2); and that such organisms are not peculiar to Philadelphia water is evident from the many reports to be found in the literature.

Preliminary study indicated that the organism in question possesses the properties of the aerobic, spore-forming, aerogenic bacilli studied by Porter, McCleskey and Levine (3) and which at present are grouped in Bergey's *Manual* (4) under the genus *Aerobacillus*. It differs from the reported species, however, in those characteristics shown in Table 1. In view of these differences, it is believed that the bacillus which has been isolated is an intermediate form and is tentatively designated, pending further study, as *Aerobacillus schuylkilliensis*.

No attempt has been made to study the pathogenicity, resistance to chemical disinfectants and survival period of the organism in question. A more detailed description of the growth and physiological reactions of *A. schuylkilliensis* is available from the writer.

Summary

1. A gram-negative, aerogenic, sporulating bacillus has been isolated from the filtered, chlorinated water of the Roxborough Filter Plant of the Philadelphia water works system. The characteristics of the organism are such as to place it in the genus *Aerobacillus*.

2. It is believed that the organism is of a hitherto unrecognized species

A contribution by George M. Eisenberg, Chief Research Bacteriologist, Ozone Processes, Inc., Philadelphia.

since it does not conform in all respects to any of the previously described *Aerobacilli*. While the organism possesses some of the properties of *A. macerans* and some peculiar to *A. polymyxa*, it cannot be classified as either of the two. The tentative name of *A. schuylkilliensis* is suggested.

3. The characteristics differentiating *A. schuylkilliensis* from *A. macerans* are its inability to attack sorbitol and its ability to form hydrogen sulfide, coagulate and partially peptonize litmus milk and liquefy gelatin.

The characteristics differentiating *A. schuylkilliensis* from *A. polymyxa* are its inability to ferment rhamnose with the production of acid and gas, production of hydrogen sulfide, failure to form acetyl methyl carbinol and terminal, as compared with central, spore location.

TABLE 1

Differential Characteristics of Aerogenic Sporulating Bacilli

CHARACTERISTICS	CULTURE DESIGNATION			
	20	16	*A. macerans*	*A. polymyxa*
Sorbitol	No action	No action	AG	No action
Rhamnose	AG	AG	AG	No action
Hydrogen sulfide	+	+	−	−
Gelatin liquefaction	+	+	−	+
Acetyl Methyl Carbinol	−	−	−	+
Litmus Milk	AG-RCP	AG-RCP	AG-R	AG-RCP
Spore Location	Terminal	Terminal	Terminal	Central

AG—Acid and gas C—Coagulation
R—Reduction P—Partial peptonization

4. The organism is capable of causing positive presumptive tests which are not confirmable in the course of routine bacterial water analyses.

5. The survival of *A. schuylkilliensis* in water which has been chlorinated to a residual of from 0.1 to 0.2 ppm. indicates its resistance to chlorination to the degree practiced in the production of the water supply where it is found.

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Relation of River Dams to Community Water Supplies

By W. G. Stromquist and L. H. Clouser

IT WOULD appear that, for a discussion of the relationship of river dams to community water supplies, no better approach to the subject could be made than to utilize as a background the experiences obtained from direct contact with such problems in so far-reaching a development as that undertaken in the program of the Tennessee Valley Authority. The effects of the authority's dams and reservoirs on public water supplies throughout the valley area are numerous and of varying complexity and technical detail. Recognizing these effects, the T.V.A. Technical Staff has given more than careful consideration and study to the problems which arise and to the methods used in the solution of these problems. It is necessary to understand, however, that the limitations in a course of action proposed by the authority are imposed by law from which there can be no deviation. The engineer is confronted from the start, therefore, not only with devising a general solution from the broader technical aspects of the problem, but with devising an effective solution within the allowable legal limitations.

As a basis for applying remedial measures to offset these reservoir effects, reference is made to Section 18 of the Tennessee Valley Authority Act which states that the authority ". . . is hereby authorized and empowered in the exercise of the powers of national defense in aid of navigation and in the control of the flood waters of the Tennessee and Mississippi Rivers, constituting channels of interstate commerce, to exercise the right of eminent domain for all purposes of this act, . . . and to negotiate and conclude contracts with states, counties, municipalities, and all state agencies and with railroads, railroad corporations, common carriers, and all public utility commissions, and any other person, firm, or corporation for the relocation of railroad tracks, highways, highway bridges, mills,

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ferries, electric light plants, and any and all other properties, enterprises, and projects whose removal may be necessary in order to carry out the provisions of this act. . ."

Types of Property Damage

This section of the act requires further explanation in that it concerns only such damage suffered by a direct taking of property, which is more commonly or loosely known as direct damage. In order to constitute an enforceable liability against the Government for a taking, the damage suffered must constitute an actual, permanent invasion of the land or interest involved, amounting to appropriation of and not merely an injury to the property. An injury to the property, not accompanied by a permanent invasion sufficient to constitute a taking, is considered as consequential or indirect damage, liability for which, insofar as the Government is concerned, has not been sustained by the courts. The authority is concerned, therefore, only with direct damage, although it must be said that in some cases it has been more than liberal in its interpretation of the type of damage suffered.

To clarify further the difference between the two types of damage, concrete examples may be cited: A municipality may have its present source of water supply and its pumping station permanently submerged under future reservoir conditions. This clearly constitutes a direct damage amounting to a taking, and the authority accordingly attempts in any case of this kind to negotiate a settlement contract providing for the relocation of the affected portions of the system. On the other hand, a municipality may lose a portion of its water revenue because some of its consumers may be forced to move from the town or well beyond the economical limits of the distribution system because of the reservoir. The courts have held that such loss or damage is indirect and consequential, as distinguished from a direct taking, and since there is no appropriation of municipal property, but merely an indirect injury suffered through loss of revenue, no liability can be recognized by the authority.

Remedial Measures

It is obvious from the foregoing discussion that while the effects of river dams on public water supplies may be many, the T.V.A., or any other branch of the Federal Government engaged in similar work, is definitely limited in the extent to which it may apply remedial measures.

The authority has followed the practice of negotiating settlement contracts providing for the adjustment or relocation of affected structures, in preference to exercising the right of eminent domain. The settlement contract operates to compromise and settle all claims which the injured

party may have against the authority by reason of reservoir damage to the former's facilities. The purpose of the contract is to settle and dispose of these claims in an equitable and mutually satisfactory manner through the payment of a consideration by the authority in exchange for a release from all claims for damage. Payment by the authority may be made by cash or by the performance of work, or by a combination of both cash and work. Where performance of work constitutes the consideration, the authority usually undertakes the work with its own forces. This method of settlement obviously results in a number of benefits to both parties, most important of which are a betterment to the system of the injured party and the elimination of further liability by the authority.

Where adjustments or relocations are definitely indicated, the authority has proceeded on the basis of providing equivalent facilities. Theoretically, this would require the replacement of existing material in kind. In practice, however, it is almost impossible to accomplish this feature because of the character of structures involved. Adjustments, therefore, inevitably result in decided improvements to the affected structures.

It is to be expected that in a river improvement program such as that carried out by the T.V.A. a number of public water supplies would be affected by the backwaters created by the dams. The effects upon the water works systems have varied considerably, and no two problems have been alike. The adjustments have varied from fairly minor changes in intakes to a complete change in the source of supply with reconstruction of all but the distribution system.

Reconstruction Projects Involved

Complete reconstruction has been necessary where the source of a public water supply has been a spring which would be flooded by the impounded water. In one instance, it was necessary to replace such a spring supply with a new supply taken from the Tennessee River which required the construction of a complete filter plant. A brief statement of some of the problems which arose and how they were solved will indicate that the engineering, together with the legal, financial, and other aspects, created some rather complex problems requiring intensive study and extensive negotiations with the owners of the water works, whether municipal or private utilities.

At Decatur, Ala., the plant consisted of an old steam and electric pumping plant, filters, clear water reservoir, and a comparatively new sedimentation basin. The pumping station and part of the clear water reservoir were below the normal pool levels of Wheeler Reservoir. A cash settlement was made in this case; and with additional funds the water company rebuilt the entire plant with the exception of the sedimenta-

tion basin. As a result, the town was provided with a modern, compact plant which was a great improvement over the former unit, much of which had been obsolete.

The water supply for Guntersville, Ala., was obtained from a spring in an adjacent creek bottom. When it was found that this source would be lost, thorough investigations were made of all springs within a reasonable distance of the town because of the desirability of maintaining a spring supply to satisfy public opinion. One spring, with a high local reputation of being strong flowing and never failing, was found after exhaustive testing to be barely adequate to serve the immediate demands of the town during an ordinary dry season. If it had been developed, the community would undoubtedly have faced a serious shortage of water after a continued period of rainfall deficiency such as is now being experienced, and would have had no provision for supplying future demands as the town continued to grow. Water is now taken from the Tennessee River, the intake being located immediately adjacent to a bridge pier in the main channel to minimize so far as possible the effect of pollution from local surface drainage. A complete new filtration plant of modern design was installed, and, despite some scattered objections to drinking river water at the inception of the project, the new water supply is apparently entirely satisfactory to the consumers.

The spring from which Kingston, Tenn., secures its public water supply will be flooded by the Watts Bar Reservoir. Here again, thorough investigations were made of a number of springs in the vicinity of the town. As in the case of Guntersville, the spring favored locally was found to be inadequate as a dependable source of water. A considerable amount of exploratory drilling was also done in an effort to develop a suitable well supply. Studies were made of using water from either the Tennessee River or the Clinch River, but this would have involved a difficult operation problem and a continuous expense for the treatment of a water polluted by domestic and industrial waste. It was finally necessary to develop a spring several miles from the town from which the water is now brought by gravity to a new pumping station. The new supply does not have the most desirable location relative to the town, but the spring was the only adequate source of supply which could be developed at a reasonable cost. The ultimate locations of the various structures were such, however, that a decided improvement to the distribution system layout was automatically effected.

At Morristown, Tenn., part of the supply is obtained from the Holston River. The filling of the Cherokee Reservoir will fully submerge the raw water pumping station and present intake. Since this is a storage reservoir with a possible variation in water level of about 90 feet, it was neces-

sary to provide new intake structures and pumping equipment to meet these extreme conditions.

This reservoir will also flood the spring and pumping station from which Jefferson City, Tenn., secures its water, and another spring at the head of Mossy Creek is being developed as a new source of supply. The water from the new spring has some decided turbidity following periods of rainfall, and is also fairly hard, as is the case with the present supply. The new plant under construction for the city will include water softening rather than merely filtration to remove turbidity. The location of the new supply main connecting the softening plant and distribution system will also automatically effect a decided improvement to the distribution system, particularly from the standpoint of fire protection.

Problems similar to those described above have also existed at Sheffield, Ala., Murphy, N.C., Rockwood, Tenn., and Harriman, Tenn., in addition to those involving numerous small private supplies throughout the valley area.

Problems of readjustments to public water supplies and sewerage systems have occurred in all the main river reservoirs built or under construction by the authority. The least of this type of work will be in the largest reservoir, the Kentucky, where no public water supplies will be affected and only a relatively minor adjustment of an outfall sewer will be required. Readjustments were necessary in the Hiwassee and Cherokee Reservoirs but none in the Norris, and none will be required in the four reservoirs now under construction in the Hiwassee Basin. As already indicated, each case has presented its own peculiar problems requiring the use of both judgement and ingenuity to solve the problems adequately and economically within the prescribed limitations. Legal and diplomatic talents have also been essential to prepare the contracts and carry out the negotiations so that the final agreements will be satisfactory both to the community and the T.V.A.

Effects on Water Supply Characteristics

The effects of dams on public water supplies are, of course, more direct and apparent with respect to the flooding of parts of the existing system. Further consideration must be given to the effects of backwater after the reconstruction of the system is finished, the dam completed, and the reservoir filled. In changing conditions from those of a flowing stream to a series of artificial lakes, the physical, chemical, and biological characteristics of the water are changed. This will in turn affect the treatment of public water supplies obtained from these sources.

The sedimentation which occurs in impounded water will result in lower turbidity of the raw water. This may, at times, make effective

coagulation more difficult. The conditions of a reservoir as compared to a flowing stream are also much more favorable for the development of algae and microscopic organisms which cause tastes and odors. It is to be expected, therefore, that more trouble will possibly be experienced with objectionable tastes and odors when the water is taken from an impounded reservoir than was the case when it was taken from a running stream. The raw water, however, will be of more uniform quality and not subject to sudden and extreme variations requiring immediate changes in the treatment as was the case before impoundage. Another advantage of impoundage is the fact that generally there will not be as wide variations in the head against which the raw water must be pumped. There are exceptions to this, as in the case of Morristown, where the water is taken from a storage reservoir; but with this exception, the variations in water level are rather limited so that, as compared with differences between low and flood stages of a river, the lift of the raw water can be considered rather uniform. Impoundage in every case has further effected substantial savings in power costs due to an over-all reduction in pumping head. Finally, there is no water shortage problem when the supply is taken from the reservoir.

T.V.A. Readjustment Procedure

It has been the practice of the authority, in preliminary planning, to explore the possible effects of the backwaters on public water supplies and sewerage systems. When a project is authorized by Congress, detailed studies are made and a report describing the system and the extent to which it will be affected by the impounded waters is prepared. This report, with a general outline of proposed adjustments, is submitted to the health department of the state in which the project is located, for review, and is discussed in person with the staff of the sanitary engineering division. By this procedure, it can be expected that the detailed plans will be developed in accordance with the requirements of the state health department and will be given final approval with a minimum of changes, as compared with complete detailed plans and specifications developed without the benefit of this collaboration. It is believed that this procedure has been very satisfactory to the state health departments, as well as to the particular communities involved; and it has been a definite advantage to the authority in expediting the approval of plans and the completion of the necessary adjustments to public water supplies.

In the prosecution of the T.V.A.'s adjustment work acknowledgment must be made of the assistance and co-operation of the various state departments of health in concluding satisfactory solutions to the many

problems encountered. Since a greater portion of adjustments, both to water works and sewerage systems, has been necessary in Tennessee than in the adjoining states, appreciation is expressed in person at this time for the excellent co-operation given by Howard D. Schmidt, Director, Division of Sanitary Engineering, Tennessee Department of Public Health, and his staff. He has given the authority the benefit of his experience and his intimate knowledge of water supply problems in Tennessee and a sympathetic understanding of the limitations of the T.V.A. in making necessary backwater adjustments. His co-operation has been particularly valuable in the readjustments of water supplies and sewerage systems in the Cherokee Reservoir area. This is a national defense project with a very close construction schedule. In spite of reduced personnel and great pressure of work, however, the approval of plans on this project has been greatly expedited by Mr. Schmidt. Without his help, there could readily have occurred delays which would have affected very seriously the completion of the entire project.

The Development of a Sound Water Rate Structure

By William S. Herbert

ANY water department should receive an annual gross revenue adequate to cover: (1) necessary interest on and amortization of any bonded debt; (2) all operation and maintenance costs of the system; and (3) the cost of normal routine extensions and improvements to the system. The financing of major improvements can best be handled through bond issues. In this way, the cost is borne by those directly benefited. The cost of the water works system should be distributed to the consumers and the taxpayers in fair proportion. The consumers pay through established rates for water. The taxpayers, through the property levy, pay for fire protection service and general benefits accruing from a water system.

To make a worthwhile rate study, it is essential that the water utility have a good accounting system. Only in this way can actual costs be determined and made available to those making the study. Fortunately, most water utilities use standard accounting forms and can easily furnish these essential data.

For the purpose of rate making, the many accounts can best be combined into five groups of items: (1) production items, including wells, intake structures, raw water pumping stations and equipment and mains, together with the treatment plant and its facilities; (2) distribution items, including high service pumping stations and equipment, storage facilities and the entire distribution system; (3) hydrants, including connections; (4) consumers services, including meters and service lines; and (5) a general item to include such things as stores, office, shop and motor and construction equipment. For each of these five groups of items, the accounts can be broken down to show the capital investment, debt requirements, and the full operation and maintenance costs. Such data for a period of several years previous to the time of the rate study should be assembled and used. In this way, trends of costs can be determined,

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and large expenditures of one year can be averaged against smaller outlays of other years. With a comprehensive plan for normal extensions and improvements, allowances for their costs can be included with the other costs.

Equally important to a rate study are complete records of pumping and use. The summation of individual meter readings will give the quantity of water upon which rates must be charged. The quantity measured by the master meter is that upon which production costs must be based. Any difference in these two quantities is lost water, which may frequently run as high as 25 per cent of the total quantity produced, even in well operated systems.

No mention has been made of profit or depreciation. In a municipally owned system, there is no reason for a profit since the users and taxpayers are the owners. If any sizable surplus, for which no immediate use is apparent, is accumulated it can too easily be diverted to uses entirely separate from the water system. While most utility regulating bodies permit the charging of depreciation, it seems unfair to burden the users of a system with the amortization of their debt and at the same time charge them to build up a fund to replace the system. It seems more reasonable to use the depreciation allowance for the financing of normal improvements and extensions and to finance major improvements, as they become necessary, by bond issues. The usual depreciation allowance, averaging $2\frac{1}{2}$ to 3 per cent for the entire system, will ordinarily be adequate to cover normal extensions.

The City's Portion of Water Department Costs

In the actual formulation of a rate structure, the first question to be asked is: "How much shall the city as a whole pay toward the costs of the water system?" Such charges have been made under several names including the very poor one of hydrant rental and too often they have not been explained to the taxpayer. During the trying days of the early 1930's many cities ceased paying these municipal service charges and left the whole burden of cost on the shoulders of the consumers. This resulted in either an increase in rates, a decrease in service or a postponement of improvements. Equally unfortunate has been the fact that many cities have not returned to their former practice of paying their share of the water utility costs.

The direct benefit of the utility to the city as a whole is one of fire protection. Fire protection places a heavy demand on a system for a relatively short time. Further, the actual quantity of water used is small compared to the total use. The charge, therefore, must be a capacity rather than a use charge. The utility must be able to deliver the water

when needed to maintain low insurance rates to the city. Water works practice standards indicate that the costs chargeable to fire protection may be determined most equitably by the ratio of maximum fire demand to the total combined demand for fire and all other uses. In other words, if the fire demand were 3 mgd. of a total demand of 10 mgd., the city should pay 30 per cent of the costs applicable to providing the 10-mgd. capacity. The maximum demand for all other uses should be that occurring during a five-day period of maximum use, this amount added to the underwriter's fire requirement giving the total demand to be provided.

In determining the costs applicable to provision of total capacity which constitute the basis of the charge to the city for fire protection, a number of factors must be considered. First, since the actual use of water for fire fighting is small and since no additional labor is involved in its supply, maintenance and operation costs may be omitted from production and distribution expenses before assigning a portion of debt service and extension costs to the city.

Production items, too, must be considered carefully on the basis of actual practice. If there are storage facilities, such as elevated tanks or underground reservoirs, in the distribution system, the production plant will not be called upon to meet the full fire demand on top of the maximum normal use. This being the case, the percentage chargeable to the city would be less than the 30 per cent previously indicated. The underwriters set up as adequate a storage of 10 hr. fire flow in addition to other storage capacity. With such storage, the fire demand could be reduced to $\frac{10}{24}$ of 3 mgd., or 1.25 mgd. Adding this to the demand of 7 mgd. makes 8.25 mgd., so that only about 15 per cent of the costs would be chargeable to the city. The balance of debt service and extension costs plus all operation and maintenance costs are chargeable to the users. Dividing this charge to the consumers by the quantity of water produced will give a unit production cost of water.

The distribution items must have capacity to carry the fire flow plus the maximum flow for all other uses. In this case there is no relief such as was possible for the production items. The city should therefore pay the 30 per cent charge set up above. The consumer will then pay the balance of debt service and extension costs, all operation and maintenance costs plus the production cost of lost water. The sum of these costs divided by the quantity of water sold gives the unit distribution cost of water. No water should be sold at less than the combined production and distribution unit cost.

All cost applicable to fire hydrants should be paid by the city. They exist solely for fire fighting purposes even though they may be used to fill street sprinklers and for some other uses. Likewise some percentage of

the general costs should be charged to fire protection. The exact percentage of these is difficult to determine, but it would seem not unreasonable to allocate from 25 to 40 per cent for this purpose.

The Consumer's Portion of Water Department Costs

All costs relating to consumer services should be paid for by the consumers as should the balance of the general costs. These two costs should be borne by the consumers equally and not on a basis of water used. The cost of reading a small meter is the same as for a large meter. Billing, collecting and accounting costs are the same per meter or bill. In metered systems about 90 per cent of the meters will be of the smallest size. Costs of maintaining and repairing meters will be fairly constant regardless of size. Only in the first cost will there be differences due to meter size. Therefore, it seems entirely reasonable to divide equally among all users the cost of consumers services and their share of the general costs.

The ideal way to bill the consumer would seem to be to make a flat service charge equal to the costs just set forth and then make a consumption charge for each unit of water used, this charge to equal the unit production and distribution costs. The difficulty with this plan is that too many people are wary of "service charges." They can see no service being rendered and feel that they are being cheated out of this amount of money. Also, since the unit cost of water is relatively low, careless use may result.

It is, therefore, easier to set up rates on a step basis, each succeeding step in the rate structure being larger and carrying a lower rate. These steps and their rates can be determined from a water cost curve, which is determined simply by dividing the total cost of any quantity of water by the quantity to get an average cost per unit. Unit prices are then plotted as a curve against quantity, this curve gradually approaching the unit production and distribution cost as the quantities increase. With an infinite number of steps, a rate curve identical to the cost curve could be obtained. Actually, only three or four steps should be used. This procedure simplifies accounting and will usually give a rate curve very close to the cost curve.

Experience in metered cities shows that about 20 per cent of the small consumers will use a very small quantity of water. At the start of the rate structure there should be a minimum charge large enough to cover the costs equally assessed to each user, plus the cost of the quantity of water allowed under the minimum bill. The first step should include the quantity of water allowed in the minimum bill and should be small enough to permit a large number of small users to exceed it to get into the

second step where lower rates prevail. The size of steps and the unit cost for each step can be determined from the cost curve. The length of step may well vary from one city to another and rates should be such that the rate curve does not fall below the cost curve.

Water bills should probably be rendered on a quarterly basis. This makes for a reasonable amount of office work and, at the same time, keeps bills relatively low, so that they can be paid easily by the consumer. It is the author's belief that established rates should be net and that a penalty for delinquent payment should be made. The result will be the same as though a gross rate with a discount for prompt payment were used. The scheme to be used, however, is to be determined largely on the basis of local sentiment.

Rate structures should be reviewed critically about every five years. Adjustments should be made to insure an adequate income to the utility and at the same time to distribute the costs as equitably as possible to the consumers.

Discussion by *Louis E. Ayres.* * In contrast with the present day views which Mr. Herbert has presented, the writer feels that it will be interesting to comment on the changes in viewpoint, over the last 25 or more years, on the two questions which must be answered in fixing any rate schedule: "How much gross revenue should be raised for the support of the water works?" and "On what bases should this revenue be collected from the several water users and taxpayers?"

In regard to the question of amount of gross revenue, much of our thinking in the past was based on the assumption that no distinction was to be made between a privately and a publicly owned water works. It was felt that a privately owned water works was entitled to a gross revenue "such as will provide for the cost of economical and efficient operation, taxes and depreciation, and a fair return on the fair value of the property devoted to public use." Similarly, it was argued that a publicly owned plant should earn, in addition to its operating expenses, interest and depreciation on the *entire plant investment*, and that where rates were only sufficient to meet the operating charges and interest on the outstanding bonds, they yielded "less than cost."

In 1917 one water works consultant expressed the opinion that this theory would result "in constantly increasing surplus revenue, and ultimately part of the surplus should be dedicated to other non-productive public purposes, such as supplying libraries, hospitals and parks." How many water works men would like to add interest and depreciation on all debt-free plant to their present department income? Such a policy would

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be helpful today in many communities now struggling under the 15-mill tax limitation, if the water works surplus were devoted to the support of other city departments. Fortunately, such an extreme practice never became general with water works properties.

It is fair to say, however, that the tendency in many systems has been to try to operate on too low a gross revenue. Receipts should be sufficient to pay all fixed and operating costs and to build up at least enough surplus to meet *normal* extensions. When the management of a water works is short of cash for extensions, adequate service will not be provided. What normal extensions are and when the water works should be required to go to the people for the approval of a bond issue to make improvements have always been moot questions. In the new Ann Arbor rate schedule, the answer was that sufficient surplus should be accumulated to anticipate all reasonable extensions to the *existing* system over several years into the future, and that only a *major* change, such as a new source of supply, would necessitate the approval of a bond issue.

Regarding the proper distribution of the costs of a water works among the several classes of consumers, too, viewpoints have changed. Twenty years ago a prominent consultant said: "A large consumer is profitable at any rate which produces a result that will add to the net revenue of the plant even though the rate is below the average." Such a viewpoint was fairly common at one time and its origin was in the struggle for business and profits of the privately owned water company. Its effect was felt in the rate schedules of both privately and publicly owned plants. The result was a wide range in the unit charge for water as between the large and the small user. The same tendencies have been present in electric rates and their development has affected our thinking regarding water rates.

The problem has been to determine the unit cost of supplying water to a household using only 200 gpd. as contrasted with the unit cost to the factory using 10,000 gpd.; and almost any answer can be found based on the premises assumed. In 1905 the Coffin Committee report of the New England Water Works Association proposed a basis which was the forerunner of the "service" or "demand" charge theory of many later rates, although the exact Coffin method was never generally adopted. This plan was to assess all costs "which are affected but little by the amount of water used on the frontage of the lot on one street, and without regard to the amount of water used. In addition to this assessment, a certain price per 100 cu.ft. or per 1,000 gal. was to be charged for all water used through the meter." The report assumed that in ordinary cases about half the gross revenue would thus be raised by frontage assessments and the balance through water sales. The effect of such a theory would, of course, be to

place an undue burden on the small home and to provide cheap water to the large user.

Later, the "demand" charge basis assumed that all interest and depreciation, and such part of the operating costs as is independent of the amount of water pumped, should be distributed among users in proportion to their capacity to demand water of the system. The consumer's demand was to be measured by the carrying capacity of his meter. A $\frac{5}{8}$-inch meter had a carrying capacity of 1.0 and a 6-inch meter, of 60. This was a more scientific basis for distributing "demand" costs than the frontage assessment basis, but the theories of "demand" or "stand-by" or "ready-to-serve" charge had to be applied with judgment or the result still tended toward too wide a spread in the unit charge to the small as compared with the large user. Obviously, such bases for rates were impossible to explain to a council or to the public.

These conditions resulted in an extreme public reaction which demanded that water be sold like sugar, at so much per pound, or like gasoline, at so much per gallon, and at the same price to all consumers. And this public demand has had its effect on both electric and water rates. Not long ago electricity was sold to water pumping stations on the basis of a demand plus a current charge. Now, frequently the demand charge is omitted as a concession to municipal service. The demand charge of electric utilities, logical as it may be, remains one of the principal sources of consumer objection, particularly during periods of business depression.

Fire Protection Charges and Joint Billing

Another item in the water rate controversy has been the charge for fire protection. It is an obvious fact to water works men that a considerable part of the plant investment is required to provide fire protection, yet but few municipalities have ever collected from taxes anything approaching the amount that water works experts have computed as properly assessable for fire service. In recent years in Michigan, in fact, the hydrant rental or public service charge has been reduced or eliminated from the rate structure of publicly owned plants. This is an unfortunate trend, arising out of political considerations and the financial difficulties of our cities. Similarly, it will bear repeating that the municipality should pay its publicly owned water works for all other public uses of water; so-called "free water" should be eliminated.

Recently, with the placing in operation of many new sewage treatment plants, there has been inaugurated the procedure of billing water service jointly with sewage service and on the basis of the water meter reading. Not all of the water pumped by the water works reaches the sewage treatment plant. Some is lost by leakage from water mains and services.

Water used for sprinkling does not reach the sewers. Water used for cooling in Ann Arbor, Mich., with a separate sanitary system, is discharged largely into storm sewers. Correcting for these factors, a simple method of determining a unit sewage rate would be to divide the total number of units treated into the total cost of treatment. This would be, in effect, a basis identical with "the sale of sugar, at so much per pound, and the sale of gasoline, at so much per gallon." There would be no differentiation in the *unit* price as between a household and a large laundry, although the householder would buy his gasoline in 10-gallon lots and the laundry, with its fleet of trucks, might buy its supply by tank car at a much lower price per gallon. There is a problem here that is not satisfactorily answered by a single unit rate to all users of sewage service.

Ann Arbor Rate Structure

A review of the bases upon which the new rate schedules for Ann Arbor were determined will give some idea of how these theories work in application. First, estimates were prepared of the interest and bond requirements and the operation and maintenance costs, for the next five years, chargeable to production, distribution, consumers' services, fire hydrants and connections and general and overhead expenses. Next, estimates under the same groupings were made on the cost of plant extensions, including those expenditures clearly needed within 5 years, those probable within 7 years and those possible within 10 years, assuming the current rate of increase in water consumption and anticipating the development of certain areas with homes. These estimates indicated that about 2 per cent of the total present capital investment should be allowed annually for these needs.

Following this, an estimate was made on the cost of fire protection chargeable to production and to distribution. The basis for this estimate was to assume a water demand for fire in accordance with the underwriters' requirements and to charge fire protection with that portion of the "fixed" costs under production that the fire demand increased the total demand on the softening plant for all other uses; and with that portion of the "fixed" costs under distribution that the fire demand increased the total demand on the distribution system for all other uses. In this case, a large gravity reservoir between the plant and distribution system sufficed to distribute the usual 10-hour fire demand over a day's operations, but the distribution system would be required to meet the maximum hour. To the total so obtained was added the annual cost of operating and maintaining existing hydrants and installing new hydrants, together with a proportionate share of the general and overhead costs. The totals so computed amounted to about 10 per cent of the total production costs, 25 per cent of the total distribution costs and 18.5 per cent of the gross revenue.

The remainder under production costs, after subtracting fire protection, divided by the total gallons of water produced, gave the cost per gallon at the plant outlets; and the remainder under distribution costs, plus the cost of the unaccounted-for water, divided by the total sales, gave the unit cost of distributed water at the consumers service. The sum of the production cost and the distribution cost gave the base sale price to all consumers.

There still remained to be distributed the expense involved in connection with operating and maintaining consumers' services, reading, billing and collecting and the proportionate share of general and overhead expense chargeable thereto. This total was distributed equally among all users. No distinction was made on size of meter. The amount was $4 per year or $1 per quarter per meter.

In the effect, then, a rate similar to that proposed in the Coffin Report of 1905 is involved. With these rates, each user buys his water at 7 cents per 100 cu.ft. and in addition pays his $1 per quarter. Instead of allocating half the gross revenue to the service charge as did the Coffin Report, however, only 18.5 per cent has been allocated. On the Coffin basis, the user of 1,500 cu.ft. of water per quarter, assuming the same fire protection charge, would have paid about 21.6 cents per 100 cu.ft., and the very large user, about 4 cents per 100 cu.ft., a ratio of about 5 to 1. On the Ann Arbor basis, the ratio is about 2 to 1. In other words, on a simple and logical basis that may be explained easily to the public, a smaller gap between the unit charge to the small as compared with the larger user, than has heretofore prevailed in many rate schedules, has been justified. One can say to the man on the street that, in effect, water is being sold like sugar or gasoline.

The bill is not, however, rendered as a service charge and a use charge. A cost curve was plotted and steps fitted to the cost curve as closely as practicable. The gross steps adopted, subject to 10 per cent discount, were as follows:

First 1,500 cu.ft. per quarter	15 cents per 100 cu.ft.
Next 23,500 cu.ft. per quarter	9 cents per 100 cu.ft.
Next 475,000 cu.ft. per quarter	8 cents per 100 cu.ft.
Over 500,000 cu.ft. per quarter	7 cents per 100 cu.ft.
Minimum Charge per quarter	$1.50

For sewage rates, the same steps were adopted, with a charge of about 56 per cent of the corresponding water rate. This means that the householder in the first step pays a net of 7.65 cents per 100 cu.ft. and the very large user gets down as low as 4 cents. The average cost of treating sewage was calculated to be about 5 cents per 100 cu.ft. of estimated wastes to the sanitary sewers or 4 cents based on volume treated at the sewage plant.

Accounting Organization of the North Jersey Water District

By M. M. McLaughlin

FINANCIAL problems and costs, whether applicable to an individual system serving one community or a district supply serving several communities, have much in common, varying significantly only in those features incidental to single or multiple ownership. In the case of single ownership, of course, the capital expenditures have but one source of origin, while in the multiple-ownership project, as stated in the Statute creating and governing the North Jersey District Water Supply Commission, "The cost of the construction or acquisition of said water supply shall be borne by the contracting municipalities in proportion to the amount of water contracted to be taken in the contract between each of said municipalities and the said district water supply commission."

In its Wanaque Project, this commission contracted with the various participants for allotments of water on the following basis:

Participant	*Allotment, in mgd.*
City of Newark	40.50
City of Paterson	20.00
Town of Kearny	12.00
City of Passaic	11.00
City of Clifton	6.75
Town of Montclair	5.00
Town of Bloomfield	4.00
Borough of Glen Ridge	.75
Total Contracted	100.00

Nothing in this breakdown indicates the necessity for any unusual accounting procedure with relation to the distribution of the cost of the entire project. Normally, the participants would be obliged to bear the

A paper presented on October 16, 1941, at the New Jersey Section Meeting, Atlantic City, N.J., by M. M. McLaughlin, Auditor, North Jersey District Water Supply Com., Wanaque, N.J.

cost in proportion to the allotments contracted, but the very nature of the project precluded the distribution of capital expenditures on the precise allotment basis.

Under the general terms of the contracts, the participating municipalities share in the cost of the project only up to the point at which they take off their supplies of water and, presumably, each municipality's interest ceases below its take-off. One outstanding exception to this formula was the cost of a balancing reservoir for which the contracts between the commission and the participating municipalities had made no provision. Although this reservoir was located at a point below the take-off of Paterson, Passaic and Clifton, it was, in the collective opinion of the engineers representing the participants and the commission, of mutual benefit to all participants; therefore, all participants were obliged to share in its cost.

Apportionment of Costs

For the purpose of estimation of the costs of the project, the contracts between the several municipalities and the commission divided the entire project into three distinct classes:

Class A—consisting of such portions of the whole plant as were to be used in common by the contracting municipalities.

Class B—consisting of the aqueduct from Little Falls to Broad St., Bloomfield.

Class C—consisting of the aqueduct from the connection or take-off at Broad St., Bloomfield, to its terminus at the Belleville Reservoir.

During the progress of construction, a supplemental contract was negotiated, dealing with the reinforcement of the aqueduct and the establishment of pumping equipment. Certain modifications and regulations with respect to the cost distribution were emphasized in this contract. It should be observed, too, that, in establishing the final distribution of construction costs among the several participants, due consideration of location and possible benefits to be derived from the use thereof were important factors but were subordinated to statutory regulations and provisions of the three contracts between the participants and the commission, thereby reducing theories to a minimum.

As a final basis for the proper apportionment of costs to the municipalities, the work was further refined into classes, as follows:

Class	*Description*
A-1	Wanaque Reservoir
A-2	Wanaque aqueduct from Wanaque to Paterson take-off and balancing reservoir
A-3	Pumping station

A-4 Aerator and appurtenances
A-5 Administration Building
A-6 Reinforcement of Wanaque tunnel and approaches
B-1 Wanaque aqueduct from Paterson take-off to the original Montclair take-off at Grove St.
B-2 Wanaque aqueduct from the original Montclair take-off at Grove St. to Broad St., Bloomfield
B-3 Reinforcement of Great Notch tunnel and approaches above final Montclair take-off
B-4 Reinforcement of Great Notch tunnel and approaches below final Montclair take-off
C Wanaque aqueduct from Broad St., Bloomfield, to Belleville Reservoir

Generally, the cost of each class of work has been apportioned to the municipalities sharing therein in the ratio which the daily gallons of water allotted to each municipality bears to the total daily gallons of water available for that class.

As each of the municipalities had a common interest in the Class A property, all of the participants shared in the cost of classes from A-1 to A-6. The cities of Paterson, Passaic and Clifton were not obliged to share in the capital expenditures beyond this point. The expenditures relating to Classes B-1, B-2 and B-3 were allocated to Newark, Kearny, Montclair, Bloomfield and Glen Ridge, with modifications as specified in the contracts. Classes B-4 and C were charged in their entirety to Newark and Kearny.

Determination of Water Allotments

A comparison of allotment percentages with relation to percentages of capital cost experienced by each of the participants, together with the capital cost to each, is shown in Table 1. The significant implications of these figures are varied, but the uniformity of the relation of the percentage of allotments to the percentage of capital invested is distinct, as is the fact that those communities nearer the source of supply receive the cheaper water, while distant consumers, burdened with the facilities of transportation, necessarily find the cost higher. Beyond the financial mechanics, however, the outstanding fact is that though it took years of negotiation to lay aside the traditional habit and method of each community of solving its own water supply problems, the project definitely removed the barrier, so prevalent in smaller communities, against joining larger neighboring communities in major projects. The smallest investor, for instance, obtains a water supply of $\frac{3}{4}$ mgd. at a construction cost of approximately $67.50 per mil.gal., with the assurance that, in an emergency, it may enjoy all the facilities of a plant with a yield of 100 mgd.

Provision for Additional Participant

Six months prior to the completion of the project, the City of Bayonne started negotiations to acquire a supply of approximately 12 mgd., the participants of the project agreeing to furnish the water from their respective unused allotments. The original contract between the commission and the City of Bayonne and the participating municipalities called for a minimum delivery of 12 mgd. at $70.00 per mil.gal. Subsequently, however, the contract was changed from a minimum basis to that of actual water consumed.

To provide for this additional load it was necessary to build a connecting pipe line from the lines of the Town of Kearny to the Bayonne line. This construction cost was assumed by the Town of Kearny, which

TABLE 1

Comparison of Water Allotments and Capital Investments of District Participants

PARTICIPANT	PERCENTAGE OF ALLOTMENT	PERCENTAGE OF CAPITAL INVESTED	CAPITAL INVESTMENT
City of Newark	40.50	44.17	$11,131,838.49
City of Paterson	20.00	17.46	4,400,468.82
Town of Kearny	12.00	13.42	3,383,243.35
City of Passaic	11.00	9.60	2,420,157.85
City of Clifton	6.75	5.89	1,483,233.23
Town of Montclair	5.00	4.82	1,214,665.84
Town of Bloomfield	4.00	3.91	986,052.25
Borough of Glen Ridge	.75	.73	184,781.00
Totals	100.00	100.00	$25,204,440.83

was reimbursed at the rate of $5.00 per mil.gal. of water passing through the line for delivery to Bayonne. In addition, the Town of Kearny, throughout the life of the Bayonne contract, receives $2.50 per mil.gal. delivered to Bayonne as a transportation charge, since all waters must pass through the Kearny system to effect delivery to Bayonne. It was necessary, therefore, to deduct from the rate quoted $7.50 per mil.gal., $5.00 of which applied to reimbursement of the Town of Kearny for construction of the connecting line and $2.50 to transportation charges for use of the Kearny lines. With the Town of Kearny fully reimbursed for the connecting link expenditure, the transportation charge deduction remains throughout the life of the contract.

The contract became effective March 20, 1930 and terminated March 20, 1940. The commission was inclined to distribute the net proceeds,

on the basis of the relation of the unused allotments of each municipality to the total unused waters of all the participants, with a rental charge for delivering the waters through the aqueduct below Class A property, or that portion of the aqueduct below the Paterson, Passaic and Clifton take-off. The rental charge was predicated upon the investment of the participants, at a carrying charge of 6 per cent, with relation to the amount of water delivered through that portion of the aqueduct in which the participant had invested construction funds. No rental charge was established for the Class A portion of the aqueduct as all participants were represented there on the allotment basis. The rental was calculated as $10.20 per mil.gal., divided as follows: Newark, $7.24; Kearny, $2.15; Montclair, $0.38; Bloomfield, $0.36; and Glen Ridge, $0.07 per mil.gal. delivered to Bayonne.

TABLE 2

Comparison of Division of Proceeds of Bayonne Contract by the North Jersey District Water Supply Commission and the Compromise Formulas

PARTICIPANT	COMMISSION FORMULA	COMPROMISE FORMULA
City of Newark*	$1,240,201.49	$1,122,344.29
Town of Kearny	292,461.48	281,045.90
City of Paterson	180,764.68	245,808.65
City of Passaic	99,423.99	135,173.21
City of Clifton	61,005.52	82,937.25
Town of Montclair	81,300.43	86,697.00
Borough of Glen Ridge	11,478.21	12,629.50
Total	$1,966,635.80	$1,966,635.80

* Including Town of Bloomfield.

Some of the participants, however, held that the distribution of the profits should be considered only from the standpoint of percentage of capital investment; and, eventually, a compromise between the two formulas was effected. The net proceeds from the first contract, which terminated March 20, 1940, and the second, now in effect, are distributed on the compromise basis. Table 2 shows a comparison between division of proceeds by the two formulas. It furnishes a fine picture of how such problems can be solved reasonably when sincerely approached at the conference table, and emphasizes the truth of the statement by the Honorable Frank H. Sommer, former chairman of the commission, at the dedication of Raymond Dam on March 20, 1930:

"In this provision practical effect was given to the principle that water supplies should be available to use, on equal terms, by all municipalities

that can be logically and economically served therefrom and not alone by the municipalities originally entering upon the development thereof.

"Experience under these provisions has served to fix in public consciousness the fact that the problem of water supply is, in general, no longer a local problem, but is a problem of regional dimensions. It has furthered a realizing sense of the fact that a policy restrictive of independent local self-centered municipal action may be constructive; that inter-municipal problems can be effectively and economically met only through concerted and common inter-municipal action—action that has a basis as broad as the problem; and that when the spur of necessity brings municipal officials together about the conference table it is not impossible, even though patience-trying, to secure voluntary municipal co-operation in meeting common problems."

Discussion by *J. E. Garratt.* * Rather than to attempt a technical discussion of Mr. McLaughlin's paper from the point of view of wholesale water works accounting, the writer intends, here, to present some supplementary information on various features of the Wanaque project.

As stated by the author, the cost of Wanaque water to the smallest participant is $67.50 per mil.gal. It should be realized, however, that this figure is based on the complete utilization of its share of the supply by each participant. If, then, any participant should use but half its share, the unit cost would be doubled. This has been the case in several of the communities involved. In other words, to those who have contracted for water in excess of their immediate needs, who are carrying the reserve of the supply, Wanaque water has been quite costly.

As pointed out, too, the Wanaque development creates an unusual situation, in that the communities participating must, in addition to purchasing the water, deliver it to the consumers. The cost of such delivery involves fixed charges and operating and maintenance expenses on all or part of such items as distribution reservoirs, distribution mains, hydrants, services and meters, together with commercial expenses and a share of general and miscellaneous expenditures. In Newark in recent years the total of such costs has amounted to about $65.00 per mil.gal., making the total cost of the Wanaque water to the consumer as much as, or more than, $135.00 per mil.gal.

Still another item for consideration is the fact that the *selling price* for water which costs a municipality a certain amount in purchasing it wholesale from the commission must be in excess of this figure to allow for such items as unaccounted-for water. A considerable amount of the

* Designing Engr., Div. of Water, Newark, N.J.

water purchased by the municipality never reaches the consumer, but must still be paid for by him. Consequently, if 15 or 20 per cent of the water purchased at wholesale is lost through leakage, waste, under-registration of meters, etc., the average selling price must be correspondingly increased. With a 15 per cent water loss, for instance, the wholesale price for water costing $67.50 per mil.gal. must actually be reckoned at $79.50. Likewise, at the $135.00 per mil.gal. estimate above, the average price for water delivered to the consumer would have to be about $160.00 per mil.gal. to meet expenses. In Newark, for the year 1939, the latest year for which figures are available, the average selling price for all water sold and accounted for, which met all expenses but yielded no surplus, was $144.40.

All these points are features which must be given careful consideration in dealing with agencies such as the North Jersey District Water Supply Commission. The agency must take them into consideration in setting its wholesale price, and the municipality must do so in determining its rate to consumers.

How to Make a Small Water Works Self Sustaining

By John M. Holladay

OF THE more than 200 water systems in Tennessee more than 150 are located in towns of less than 2,500 population. It is just as important to the inhabitants of these small towns and cities to have an adequate supply of potable water as it is to those who live in the large towns and cities. One of the serious drawbacks, however, is the cost and the problem of financing the construction of the works to make this possible. This was remedied to some extent by the advent of the P.W.A., which agency was able, by loans and grants, to help a great number of towns install modern water works systems.

Camden, the county seat of a small county (Benton) in western Tennessee, with 1,000 population is a typical small town. Prior to 1936 it had no adequate water system; it obtained its supply from wells and cisterns and a small pressure system serving less than 100 customers. Camden is one of the towns in Tennessee fortunate enough to obtain a loan and grant from the P.W.A. to aid in the construction of an up-to-date water works system, which was placed in operation in 1936.

The data herein given and the suggestions and recommendations made are based on the operation of a municipally owned water works system, but, with certain exceptions and some changes, they can be applied to and adopted by a system which is privately owned and operated.

Camden applied to the P.W.A. for a loan of $35,000 and a grant of $12,500 to defray the cost of its system. To pay its part of the cost, it sold to the P.W.A. its water works revenue bonds in the amount of $35,000, drawing interest at 4 per cent and due serially. The bonds are payable solely out of the revenues of the water works system and are secured by a statutory mortgage lien on the water system itself. No tax of any kind is levied on any real or personal property in the town to pay the principal and interest of the bonds and no property in the town, except the water works, is liable for their payment.

A paper presented on October 28, 1941, at the Kentucky-Tennessee Section Meeting, Nashville, Tenn., by John M. Holladay, Attorney at Law, and Chairman of the Board of Water Works Commissioners, Camden, Tenn.

These bonds, incidentally, were issued under Chapter 68 of the Public Acts of Tennessee for 1933, a statute which has been considered and declared valid by the Supreme Court in the case of *Selmer v. Allen* (166 Tenn. 476; 63 SW. (2) 663). This is a very comprehensive law and is recommended to any town which desires to operate its own water work-system. If a town can qualify under the law, it makes possible the acquisition, construction and operation of such a system.

Appointment of Commissioners

Section 19 of the act provides that any city or town acquiring a water works system under its provisions shall provide a board of water works commissioners consisting of three members, who shall be responsible for the custody, administration, operation, maintenance and control of such works; and that the board shall be created in the following manner:

At the time the governing body of the city or town (which is the Town Council, the Mayor and Aldermen, etc.) passes the ordinance authorizing the acquisition of a water works system, they shall appoint three men from among the property holders who are and have been residents of the city or town for not less than one year preceding the date of appointment. No officer or employee of the town, whether holding a paid or unpaid office shall be entitled to appointment or service on said board until at least one year after the expiration of the term of his public office. The commissioners shall be appointed by a majority vote of the governing body, the original appointees to serve from date of appointment for two, four and six years respectively from the next succeeding July 1, and successors shall be appointed for a term of six years in the same manner at the first regular meeting of the governing body in June next preceding the expiration of the term of office of the expiring member.

This is known as the "staggering" system of selecting a board and insures a continuing operating board at all times. It is a most satisfactory way to provide for such appointments. By having such a board, created in the way provided for by the act, the operation of the works is divorced from politics, and is about as free from political pressure and influence as is possible for the operation of any municipally owned and operated utility.

Duties of the Board

The operation of the works is entirely in the hands of this board, and, subject to certain limitations, it has the power, and its is the duty, to proceed with all matters and to perform everything necessary to the proper operation of the works, collection of charges for services rendered, etc. It may employ such employees as are necessary and fix their compensation, and all such employees shall do such work as the board directs. The board

may also employ engineers and attorneys whenever, in its judgment, such services are necessary, and shall keep a complete and accurate record of all meetings and actions taken, receipts and disbursements, and make reports of same to the governing body at stated intervals, not to exceed one year.

The creation of such a board is not required if the duties are performed by a similar body in existence at the time of the passage of the act, and the governing body may substitute the existing body for the board required by the act.

As chairman of such a board in the Town of Camden since its water system was placed in operation, the author has faced many problems and difficulties, but the experience has been worth the effort. It is hoped that the following description of these experiences will be of value to others occupied in similar work.

In the first place, it must be understood that the job of being a water works commissioner in a small town must of necessity be an avocation. The meager salary which may be, and which can be, paid makes it necessary for the person performing the service to have some other source of income. Under the law, the salary is limited to $25.00 per month per commissioner, and in Camden the salaries are $5.00 per month for the chairman and $2.50 per month for each of the other two commissioners. Such a position calls for public-spirited, unselfish service on the part of the citizens, for the administrative overhead must be held to a minimum if the works is to be self-sustaining.

In Camden the commissioners have asked and received the fullest cooperation from the Mayor and Alderman who are kept fully informed of all action taken by the Board Water Works Commissioners. A copy of the minutes of each meeting is furnished to them, and, in expending money in excess of certain stated amounts for extensions as well as in determining the salaries of employees, the approval or sanction of this governing body has been sought and obtained in all cases. By working in close harmony with the governing body and by keeping it fully informed at all times of the condition of the system and how it operates, friction or antagonism between the board and the governing body is avoided. That "an informed people is a satisfied people" is thus well demonstrated.

Accounting System

The accounting system is based upon three accounts in two banks. First of these is the Operation and Maintenance Fund account into which all moneys received from all sources are deposited. Out of this account is drawn by check each month the amount of the bond and interest payment required. This is then deposited in the Bond and Interest Sinking Fund account, kept in a separate bank. The use of separate banks serves the

two-fold purpose of giving both banks in town some of the water works business, thereby helping to build and keep good-will, and of providing an actual physical transfer of the funds, so there is no opportunity for a confusion of accounts. The third account is the Depreciation Fund account, to which is transferred each month, by check drawn on the Operation and Maintenance Fund account, a certain amount based on the receipts for the month. Thereby a fund is accumulated to take care of at least some of the depreciation. From the beginning of operation, in 1936, to June 30, 1941, $329.04 was accumulated in the Depreciation Fund account, and though none of this fund has yet been used, it is valuable as a "backlog" which will be ready when, as and if it is needed.

Bond Retirements

When the board took office, one of its first acts was to determine the exact amount per month that would be required to pay off the bonds as they fell due and to keep the interest paid. The interest on the bonds has been paid when due at the end of every period and $6,000 of the original issue of $35,000 has been retired. Each of these bonds has been paid before it was due, thereby saving some on interest. The bond due on August 1, 1943, has already been paid and canceled and is at present on display in the window of one of the banks.

The money which accumulates in the sinking fund should not and cannot be used for any other purpose than to pay off the bonds and the interest accruing on them. Until a month or so ago, the Reconstruction Finance Corporation owned and held the entire issue of these bonds and was very co-operative in permitting the bonds to be paid off and canceled before maturity, with no premium or bonus required. Recently, however, the bonds have been sold to a Nashville bond dealer at a handsome profit to the R.F.C., so that it may no longer be possible to pay off the bonds before they are due. In the event that the board must wait until the bonds are presented for payment in due course, some safe investment for the money in the sinking fund, which grows regularly from month to month as the money is transferred to it, will have to be determined. Until the present, the board has operated on the theory that the best investment that could be made with this money was in its own bonds which would eventually have to be paid with the sinking fund money anyway.

The utmost diligence has been exercised in taking care of the bonded indebtedness when due or before. Proof of this is evident in the fact that the 4 per cent revenue bonds on a small water works in a town of 1,000 population in a county of less than 12,000 population have already been sold by the R.F.C. at a premium. The Nashville bond dealer and the R.F.C. will, no doubt, gladly substantiate that fact.

The Board of Water Works Commissioners elected a Chairman and a Secretary-Treasurer. All checks must be signed and countersigned by these two officials. The Town Recorder has acted as Secretary-Treasurer in what might be termed a "sideline" job as it pays only $5 per month. He is responsible for all water works funds and is under a surety bond executed by a responsible company in a reasonable amount. The premium on this bond is paid by the water works and is charged to the Operation and Maintenance Fund account.

Part-Time *vs.* Full-Time Operator

At the beginning of operations in 1936, the board tried to "get by" with a part-time operator, i.e., an operator who looked after the water works when he had finished with his regular job. For some time the Mayor, a hard-working, energetic and mechanically minded person started and stopped the pump and did the little jobs which came up in connection with the operation of the system in his spare time from his own business and mayoral duties. He did a good job too. After that the Town Marshal was employed to start and stop the pumps, and extra men were hired to do the other jobs as the need arose. It soon developed, however, that, if the water works was to be successfully operated and self sustaining, some very definite arrangements had to be made about getting a full-time operator. In August 1937, then, a full-time man was employed. He is still on the job, making good and giving entire satisfaction both as operator and service man and is on duty or subject to call 24 hours a day.

As a precautionary measure, the operator was also made a member of the volunteer fire department, which, though this has no place in this paper, is one of the best functioning volunteer fire fighting outfits in any small town in the state. As a member, the operator reports at all fires, starts and attends to the pumps, and is responsible for ascertaining that a sufficient supply of water is available. As a result of the good work of the fire department and the fullest co-operation of the Mayor and Aldermen in furnishing necessary equipment and otherwise meeting the requirements of the Tennessee Inspection Bureau, the town has been rated in Class 8 for about a year now, which rating represents a considerable saving to the public by reason of the reduction in insurance premiums thereby made possible.

When the present operator was employed in 1937, he was paid at the rate of $50 per month. Since that time there has been added to his duties the responsibility for reading the meters, making out the bills, which are rendered and payable monthly, collecting delinquent bills, etc., so that about a year ago his salary was increased to $75 per month. This salary is, of course, very moderate compared with what he might be able to obtain

on a defense job in one of the two defense plants operating at "full-blast" nearby, but he has been given to understand that his job is to operate the water system and that he will be permitted to do that job without undue interference on the part of the board or the governing body, without question of his political party or preferences. In other words, it is the operator's job to look after the water works and to see that its interest is at all times taken care of, as well as to operate the system in a business-like manner, divorced entirely from politics. As a result, he has been satisfied in his job. He is interested in the work, he feels the responsibility, and is performing a worthwhile and public-spirited job unselfishly, capably and satisfactorily. Despite some attractive offers involving salaries of almost as much per week as he is now earning per month, he is still operating the water works—all because he feels that the system is partly his, that he has an interest in its success. That is loyalty to the *n*th degree.

In addition to his other duties, as outlined above, the operator is responsible for keeping a record of the materials on hand and the materials and supplies needed from time to time, and for ordering them. He also repairs and checks meters, adjusts complaints, makes new cut-ins, restores service and performs any other duties which arise in maintaining water works service.

Comparative Power Costs

Some idea of the savings that can be achieved by close supervision may be gained by an examination of comparative figures on power costs. During the first year, 1936–37, with an average of 137 customers per month, the pump used an average of 2,497 kwhr. of electricity per month at an average monthly cost of $81.80. That was when the system was taken care of by a part-time operator. During the next year, 1937–38, when a full-time operator was on duty for eleven months, customers averaged 141 per month—4 more than the first year—but power consumption was reduced to 1,370 kwhr. per month, costing $62.60. The saving then was 1,127 kwhr., or $19.20, almost enough to pay half the operator's salary. And during 1938–39 results were even better. With an average of 160 customers per month, an average of 1,347 kwhr. was consumed at an average cost of $61.91 per month.

In the fourth year, 1939–40, the average number of customers per month jumped to 176 and power consumption to 1,658 kwhr., indicating that maximum efficiency was reached at a point somewhere between 160 and 176 customers. In other words, when water service is provided to more than 160 customers, power costs will probably increase at the same rate. In that year, however, another factor entered the picture, when the electric system was acquired by the county and started operation as a municipally

TABLE 1

Camden Water Works Power Cost Chart

MONTH	1936–1937			1937–1938			1938–1939			1939–1940			1940–1941			1941–1942		
	Customers	Power Consumption, in kwhr.	Power Cost	Customers	Power Consumption, in khwr.	Power Cost	Customers	Power Consumption, in kwhr.	Power Cost	Customers	Power Consumption, in kwhr.	Power Cost	Customers	Power Consumption, in kwhr.	Power Cost	Customers	Power Consumption, in kwhr.	Power Cost
August	107	4,450	$111.75	143	2,520	$82.80	151	1,200	$59.00	170	1,670	$68.40	192	2,590	$35.34	231	3,010	$39.04
September	147	3,930	103.95	143	1,880	72.60	151	1,330	61.60	173	1,900	73.00	193	2,320	32.97	234	3,070	39.57
October	146	3,030	90.45	139	1,500	65.00	157	1,610	67.20	174	1,860	72.20	195	2,600	35.43	238‡	3,090	39.74
November	147	2,930	88.95	142	1,400	63.00	160	1,210	59.20	173	1,210	59.20	201	2,050	30.59	239	2,870	37.81
December	141	2,490*	82.35	138	1,260	60.20	160	1,110	57.20	175	1,280	60.60	201	2,220	32.09	241	2,830	37.45
January	141	2,710	85.65	135	1,220	59.40	162	1,400	63.00	174	1,250	60.00	200	2,210	32.00	244	3,010	39.04
February	138	2,010	75.15	136	1,050	56.00	162	1,240	59.80	175	1,260	60.20	201	2,680	36.13			
March	136	1,500	65.00	140	1,050	56.00	160	1,290	60.80	177	1,340	61.80	203	2,440	34.02			
April	136	1,690	68.80	142	1,070	56.40	165	1,570	66.40	179	1,450	64.00	210	2,490	34.46			
May	137	1,460	64.20	144	1,000	55.00	165	1,210	59.20	179	1,140	19.60†	209	2,160	31.56			
June	137	1,930	73.60	145	1,030	55.60	168	1,290	60.80	186	2,550	25.20	220	2,780	37.01			
July	134	1,840	71.80	149	1,470	64.40	169	1,700	69.00	188	2,050	30.59	226	2,890	37.98			
Totals	1,647	29,970	$981.65	1,696	16,450	$746.40	1,930	16,160	$743.20	2,123	19,900	$654.79	2,451	29,430	$409.58			
Average	137	2,497	$81.80	141	1,370	$62.60	160	1,347	$61.91	176	1,658	$54.57	204	2,452	$34.13			

* Expense of $2.25 for fuses not included.

† T.V.A. rates effective from May, 1940 to end of table.

‡ Data for this and following months added since original presentation.

owned utility, putting T.V.A. rates into effect. Because of this change, the 1,658 kwhr. represented a monthly bill of only $54.57. To get a true picture of comparative costs for the year, figures for the nine months operation under the old rates show that with an average of 174 customers, 1,469 kwhr. were used at an average monthly cost of $64.38.

The year 1940–41 shows even greater savings, but the application of the new rate is mainly responsible. Figures for that year, however, are interesting in that they show just how large a factor power rates really are in the cost of operating a water system. In that year, with an average of 204 customers, power consumption was 2,452 kwhr. (still 45 kwhr. under the first year) at an average monthly cost of only $34.13.

A study of these figures as detailed in Table 1 will indicate the advantages of efficient operation as well as the importance of low power rates. During the fifth year of operation, water for 204 customers was pumped with less power than for only 137 customers during the first year, and it is the amount of power consumed which really counts, regardless of rate.

Operating Expenses and Records

In regard to expenses for the 58 months of operation up to June 30, 1941, the end of the fiscal year, the board has paid out in principal and interest on the 4 per cent serial bonds slightly more than was paid out for maintenance and operation expenses during the same time: $12,250.00 being transferred to the Bond and Interest Fund account and $12,021.79, or $228.22 less, spent for maintenance and operation. A summary of all expenses for this period is shown in Table 2.

A weekly report is made by the operator giving in detail the number of hours and gallons pumped, amount of chemical used, results of the chemical tests, power consumed, and other information necessary or helpful in keeping an accurate record of information. The form used for this report, as shown in Fig. 1, is mimeographed at a small cost and the record made has been found well worth while in many instances.

Meter Reading and Collections

The operator reads the meters on or about the last day of the month and makes out the bills, showing the amount of water used, the charges due, etc. Recently the board has adopted a system of billing by government postcard. A thin sheet of paper containing the same printed information as the card is used with it for office records. The original of the bill is typed on the sheet of paper, making a carbon copy on the postcard. The card is then mailed to the customer and the original bill, together with a list of customers, the amount of water used and the amount of their bills, is turned over to the Collector, who proceeds to collect the

bills from the customers who call at his office to pay them. The list of charges is made out in triplicate, one copy going to the Collector, one to the Board of Water Works Commissioners, and one is kept by the operator for his own records. The Collector collects payments until the tenth of the month, at which time those unpaid are returned to the operator. A penalty of 10 per cent is then added to the amount of the bill and the operator, as delinquent bill collector, collects payments until the twenty-eighth of the month, when he again reads the meters. If a bill is not paid at that time the service is disconnected. Restoration of service, of course, carries with it a charge to the consumer. The services are all metered; and collections

TABLE 2

Summary of Expenses of Camden Water Works—August, 1936 to July, 1941

ACCOUNT	TOTAL FOR PERIOD	AVERAGE PER MONTH
Salaries	$4,954.05	$85.41
Labor and Materials	2,373.15	40.91
Power	3,499.60	60.32
Insurance	181.84	3.10
Repairs	446.57	7.52
Miscellaneous	566.57	9.77
Total	$12,021.78	$207.30
Bonds and Interest	$12,250.00	$211.20
Extensions, etc.	3,500.39	60.33
Depreciation	329.04	5.67
Total	$28,101.21	$484.50
Total Receipts	$28,731.59	$495.37
Total Paid Out	28,101.21	484.50
Operating Balance	$630.38	$10.87

are usually made in good order with few delinquencies, which, for the most part, are finally collected.

All collections are handled by the Collector, who is also the Secretary-Treasurer. For this service the Collector receives $20.00 per month, which, added to the $5.00 he receives as Secretary-Treasurer, gives him a fairly decent amount for his work. Of course if he were not recorder and did not have some other business out of which to make his living, he would not be able to do this. He is public-spirited enough and unselfish enough to want to serve his town and community and for that reason the department receives a great deal more than it pays for; and in fact it could not pay a full-time employee a sufficient amount of money to justify his doing the work.

The Commissioners do not handle any money; neither does the operator, except when he collects for a cut-in, in which case he issues a receipt in duplicate, one to the customer and the other to the Secretary-Treasurer when he turns over the money to him—and except what he receives as delinquent bill collector. The Collector has a record of the delinquent bill, with name and amount; and each month he reports his collections, deposits, delinquencies, receipts for cut-ins, etc., to the Commission. All these data are placed in the permanent water works file.

PUMP NO. _____

WEEKLY REPORT OF THE OPERATION OF THE CAMDEN WATER WORKS

FOR WEEK ENDING _____ 194__

	Hour Pump Started	Hour Pumped Stopped	Total Hours Pumped	Gal. Pumped Today (est.)	Total Gal. Pumped to date	Chlorine Weight	Chlorine Test	Remarks: Oil and other supplies purchased, Meter readings, etc.
	Before							Kwh. used
FORWARD	Prev. Mo.							
	Last Mo.							
	This Mo.							
	AM PM	AM PM						
SUNDAY								
MONDAY								
TUESDAY								
WEDNESDAY								
THURSDAY								
FRIDAY								
SATURDAY								
TOTALS								
METER READINGS								Now
								Last reading day
								Kwh. used this week

FIG. 1. A Mimeographed Form for Operation's Report

Purchase of Materials and Supplies

All materials and supplies are purchased at wholesale. It has been found that the salesmen representing the jobbers and manufacturers are most helpful. They are always glad to be called upon for information, prices, advice, etc.,—incidentally, they are usually glad to sell when they have the merchandise on hand. They are usually well trained men and know their business. It is recommended that they be consulted regularly and often and encouraged to call at stated intervals.

There is no padding of prices for what is purchased and as a result, no one

gets any "rake-off" on the purchases made; but the water works is entitled to and does receive the best supplies and materials at the lowest possible prices, consistent with good quality.

Co-operation With State Health Department

The state health department, its director of sanitary engineering and every representative have given the fullest co-operation ever since the system was organized. Too much praise cannot be given for the services rendered. It is most earnestly urged that every small system avail itself of the many helpful suggestions and services offered without charge by the state health department. It should be remembered that every citizen pays his part for the upkeep of these departments and if his water works system does not take advantage of the services offered, it is losing something for which it is already paying.

Incidentally, when the water works approval program was put in operation in Tennessee and approval signs were erected at the city limits on all roads leading to the towns approved, the Camden water system was one of the first ones in the state to qualify by scoring the required number of points. The signs are now posted and the community is justly proud of its record.

Summary

1. You must save pennies if you are going to make a small water works self sustaining; you must enlist the services of responsible, capable, honest and patriotic citizens as commissioners; obtain and retain the co-operation and help of the mayor and aldermen of the town, work together and with them, for they are serving the people of the community too, and usually at a great personal sacrifice.

2. Establish and collect reasonable but adequate rates and charges.

3. Employ a competent, full-time operator—one who will devote his full time and energy to the affairs of the system. He should be capable, honest, dependable and trustworthy. Usually, a man of that kind, if you can find him, will have to make a personal sacrifice too; but he will do that if he is really interested in his community and the system and not just the almighty dollar.

4. Obtain regularly a good water works magazine. The commissioners and the operator as well will be able to obtain many a good idea by reading the articles therein.

5. Have the operator attend the operators school conducted by the state public health department, or sponsored by other organizations as the case may be, and obtain the certificate issued for passing the required grade.

Pay the operators expenses to and from this school and while in attendance. It will be good money well spent.

6. Watch material, supplies and power costs. Take care of leaks promptly, even if they are on the customers side of the meter. He will thank you for it and feel grateful. It will create good will.

7. Employ a good secretary-treasurer and collector. Pay him a reasonable compensation for his work. Bond him with a good surety bond and pay the premium therefor.

8. Treat every customer the same way under the same circumstances. There is no way except the right way to do business, especially to operate a municipally owned utility. Permit no discrimination, whatever pressure may be brought to bear. Depend upon the employees to look after the interest of the system; back them up in it so long as they are right.

9. Everyone should pay a bill for the amount of water he uses—whether he be the mayor, an alderman, commissioner, employee or other. And they should pay at the same rate the other customers pay. Use the revenue from the works for the use of the system and do not divert the funds to any other purpose or use.

10. Listen to and adjust all complaints honestly and fairly, but firmly and fearlessly. Be patient and indulgent. Remember the customers own the system and if there were no customers there would be no system, and the good, efficient and capable employees would have to find another job.

11. Last but not least, join the American Water Works Association and encourage others to join too. We are all working for the interest of the people and what is good for a few will be good for that many more.

Growing Pains of a Small Town Water System

By P. D. Wilson

IN THE days of the old West, a water system consisted of the town pump and water trough in front of the trading post, and wild cowboys shot holes in "ye olde water trough," that had to be repaired with plugs whittled out by the Town Marshal. When the trading post grew into a village and was incorporated as a town, however, the old town pump was no longer able to carry the load and had to be replaced by a new system. The development of the water works in such a small town usually was somewhat as follows:

The Town Council met and voted to build a water system and to finance it by a bond issue, which, though it represented all the town could afford, limited the system to the bare necessities. To save money then, the Council planned the system without the aid of a competent engineer and without standard specifications.

A small well, a pump and a tank were then installed, and after several more "hot" council meetings, an 8-inch wood stave pipe was laid from the well to Main Street and along the street for five or six blocks; and later a few laterals of 4-inch pipe were run into the residential districts. The duties of Water Superintendent were then added to the work of the Town Marshal, and "Presto!" the town water system *was*.

During the following few years the town grew normally and the wood-stave pipe began to dispense its contents to "Old Mother Earth," until the customers had to get their water as it went by. By that time, however, the small town had been modernized by the institution of a commission form of government, the commissioners being elected on their promise to build a modern water system.

Under this new administration, after straining the town's financial resources to the breaking point, the old well was enlarged and deepened and a new and larger (10-inch) cast-iron main was installed to replace the 8-inch wood pipe. In addition a couple of 6-inch and a few more 4-inch laterals were provided to take care of additional customers. At that point the

A paper presented on May 8, 1941, at the Pacific-Northwest Section Meeting, Seattle Wash., by P. D. Wilson, Water Works Supt., Toppenish, Wash.

capacity of the system was sufficient to provide for the population of 846 and for the 17 hydrants, but the city fathers had, without a peek into the future, built that thing for which has been coined the name "bottleneck."

This, then, is the background of the system now turned over to a new Water Superintendent, whose problem it is to enlarge the bottle until it will encompass the present population of at least 4,000. His is the task of erecting a ten-ton machine on a rotten wooden floor. What his troubles are can only be hinted at here.

Difficulties Involved

The original system had an inadequate number of gate valves, and the few that were used were installed haphazardly. For instance, while the town's streets were being repaired last year, three gate valves, none of which was shown on the water department maps, were unearthed, and two of these were closed. This is a real source of difficulty, particularly when a close and fast shut-off is necessary. When the valves were opened the superintendent obtained an immediate reduction of a water hammer problem that had been giving him a great amount of trouble.

Often, too, maps of the water distribution system are untrue. Failure to locate on these maps services laid to vacant properties often results in the loss of these services to the system. Such dead services will, of course, rust out faster than live ones.

Sometimes valve gates are removed and the stems packed. This can be corrected to some extent by installing valves in the header line when new laterals are cut in.

Numerous leaks are a great loss on a 100-per cent pumped system. If a sewer flushing system is used, it should be watched very closely. A good pipe locater is a great help in saving time and money.

In a growing town it becomes necessary to extend the distribution system —a job that should be approached only after careful study and planning. Line losses must be held to a minimum and pressure and volume to a maximum. Provision should be made, too, for adequate valves and fire hydrants. If possible copper pipe should be used for services. If iron pipe is used, copper goosenecks may represent a 20 per cent saving over lead.

Collections offer a real dyed-in-the-wool problem to a small town—one which is divided into as many little problems as there are delinquents. The best "collector" is a reduction in volume and pressure, and, finally, the shut-off key.

Motors and pumps of today are almost foolproof, but they still require attention. Automatic switches that are properly installed will save time and trouble for the small town water superintendent.

Water Conditioning by Flocculation

By Samuel L. Tolman

ADEQUATE conditioning of raw water prior to filtration is essential to the production of a satisfactory filtered water. Careful attention to the design of the structures and mechanisms used in the conditioning processes inevitably results in the improvement of performance of the entire plant. No single step in water preparation is of more importance than flocculation. It is in setting up this process that the skill of designing engineers is required to make the plant adequate for all rates of flow and changes in the condition of the raw water and to make possible low first cost and minimum operating and maintenance costs.

The size of both flocculation and settling basins may be kept at a minimum if they are efficiently designed to prevent short-circuiting of flow. Rates of agitation in flocculation basins must be such that a substantially complete removal of turbidity will later be obtained in the least possible time. To secure quick and efficient settling, dense floc particles of uniform size must be formed, and water applied to the filters should contain little unflocculated turbidity. Any such turbidity will pass through the settling basins to the filters. If the design of either flocculation or settling basins is inadequate, or if operation is inefficient, either too much turbidity or an unsettled floc will pass to the filters and result in decreased filter runs and increased wash water consumption.

Attempts to overcome inadequate flocculation by overdosing with coagulant may, because of the decrease in specific gravity of the floc entering the settling basins, result in carrying more floc to the filters. Satisfactory floc formation is possible only when the correct amount of coagulant is used and when the time of mixing and rates of agitation are properly adjusted. These factors will change with variations in the raw water.

Removal of raw water turbidity requires a study of chemistry, hydraulics and mechanics. Early designers recognized the need for providing means

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A paper presented on August 8, 1941, at the Western Pennsylvania Section Meeting, Erie, Pa., by Samuel L. Tolman, Mgr. of Sales, San. Eng. Div., Jeffrey Mfg. Co., Columbus, Ohio.

of agitation for satisfactory flocculation. This was done by many devices, the most common being baffled chambers using either "around-the-end" or "over-and-under" baffles. The latter apparently were most efficient at a single rate of flow. When operated above or below this rate, however, results were unsatisfactory. Baffled mixing chambers were designed with detention periods varying from a few minutes to more than an hour. Prior to the introduction of mechanical flocculation, the idea of most designers appeared to be, first, to provide a stage of rather violent mixing, where coagulants were added to the raw water, and, second, to introduce the water gently into the settling basins, where coagulation and flocculation should proceed with as little disturbance as possible.

Recent Improvements in Flocculation Practice

It was not until 1921 that Langelier (1) showed that gentle stirring for as long as 40 min. was not only *not* harmful but that the coagulant requirement was substantially reduced from the amount required by rapid initial mixing and passing through settling basins. His experimental results indicated complete flocculation in about 30 min., but in his design for the plant at Sacramento, Calif., he recommended a flocculation period of 40 min. In his design, Langelier used four vertical, cylindrical tanks connected for series operation, the flow passing upward through the first, down through the second, etc. Each tank was equipped with a vertical shaft to which cross-arms were fastened, paddles being hung from these arms. The plant was designed for tapered mixing by operating the mixers at varying rates of speed. A peripheral speed of 2 fps. was used in the first tank and about 1 fps. in the last.

In 1924, C. P. Hoover (2) of Columbus, Ohio, showed that mixing for 75 min. at 0.3 fps. in baffled chambers was insufficient, demonstrating that mechanical mixing in laboratory apparatus at 0.6 fps. peripheral speed for 30 min. gave greatly improved results. Later, in 1932, Marsden Smith (3) installed flocculators at Richmond, Va., and reported greatly improved flocculation and substantial savings in alum, using four paddle wheels on horizontal axes placed at right angles to the direction of flow through the basin. Detention time was 70 min., and variable speed drives were used to provide paddle shaft speeds of from 1 to 3 rpm.

During the past twenty years, mechanical mixers have been installed in a large number of plants all over the country. Today it is the accepted method of pretreatment in nearly all filtration plant design. The engineer has a variety of mechanical mixing devices to choose from but nearly all fall into one of three classifications: (1) vertical shaft mixers; (2) horizontal paddle mixers, with the axis parallel to the direction of flow through the basin; and (3) horizontal paddle wheels, with the axis at right angles to the

direction of flow through the basin. Some manufacturers recommend operation of all the paddles at one rate of speed while others recommend tapered mixing by operation of successive paddle wheels at progressively reduced speeds. Baffling of the basin varies according to the standard practice of the manufacturer. Paddles are made of either wood or steel but width of blades and number and arrangement follow no fixed pattern. All of these devices are designed to create disturbances in the liquid under treatment for the purpose of mixing the coagulant with the raw water, collecting the turbidity by contact of the precipitate, and rolling together small particles into a floc of uniform size and maximum density.

Steps in Flocculation Procedure

The first step in flocculation is thorough mixing of coagulant with the raw water. The most common means of accomplishing this are the so-called flash or rapid mixers. These consist of small high speed agitators installed in small tanks through which all the raw water passes and into which the coagulant is introduced. Detention periods vary from a few seconds to four or five minutes. As the chemical reactions occur quickly, there is a possibility that, unless rates of agitation are high, unused coagulant will be included in the freshly formed precipitate when concentrated coagulant solutions are used. The more dilute the coagulant used, the greater is the probability of its being used completely; and the less is the power required for the mixing.

After the mixing of the coagulant with raw water, it passes directly to the flocculation basin, where the rates of agitation are reduced. Correct rates of agitation are a function of the mechanical device used—diameter of paddle wheels, width of paddle blades, number and arrangement of blades and speed of rotation. The theoretical detention time is fixed by the design of the basin, but the effective detention period depends upon proper baffling. Experiments by the author have shown that, with horizontal velocities of 10 fpm. or higher, through the basin, little short circuiting takes place. These experiments have also shown that the use of four tanks in series, similar to the method of Langelier at Sacramento, results in a minimum of short circuiting.

The design of one type of basin for a single flocculation unit consists of a tank of nearly square cross-section, with a ratio of length to depth of approximately 4 to 1. The long tanks show better hydraulic characteristics than do the short ones. The stirring mechanism consists of paddle wheels mounted on a horizontal axis parallel to the direction of flow through the basin. Radial arms 90 or 180 degrees apart are fastened to the shaft and wooden paddles are fastened to the arms. The tank is divided into four or more compartments by means of vertical concrete or wooden

baffles placed at right angles to the axis of the paddle wheels. Communication between compartments is provided by means of ports in the baffles at the dead center of rotation. Ports are designed to allow a maximum velocity of $1\frac{1}{2}$ fps. A rotating baffle fastened to the shaft is placed just beyond each port. The horizontal shaft is separated at the end of the second compartment and the first section is rotated at a higher speed than the last section. The paddle wheels are driven by means of chains and sprockets placed at the end of the second compartment. By the number and arrangement of paddles and the speed of rotation of shafts, varying rates of agitation are developed in the various compartments, the highest

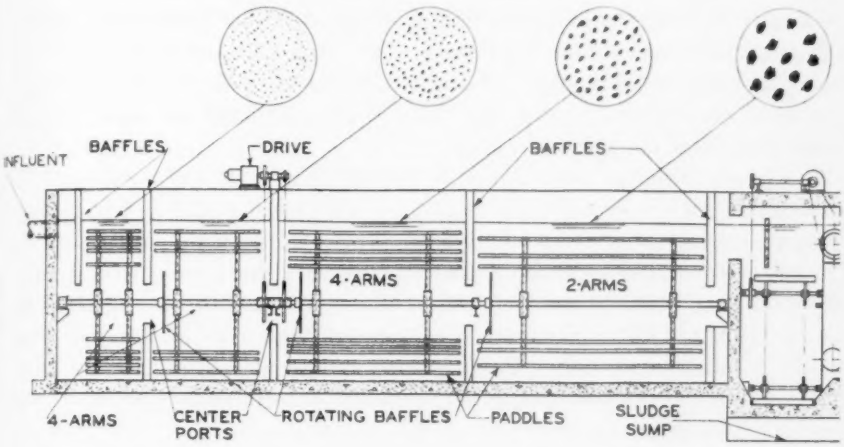

FIG. 1. Longitudinal Section Through Flocculation Basin Designed for Tapered Mixing; showing increased detention time as flocculation progresses and elimination of short circuiting by arrangement of baffles and ports

rate in the first and the lowest, in the last. Detention periods are varied in the reverse direction. Several paddle wheels can be installed in one basin without longitudinal baffles between units if adjacent paddle wheels rotate in opposite directions (see Fig. 1).

Study of Hydraulic Characteristics

The author has made a careful study of hydraulic characteristics of continuous flow basins equipped with mechanical stirring devices. This has been done by a study of the dispersion indices of various size units. The dispersion index has been defined by Morrill (4) as the ratio of time required for 90 per cent of the flow to pass out of the tank to the time required for the first 10 per cent. A high index indicates serious short circuiting. Scores of tests have been made on models of different sizes

as well as on basins under regular operating conditions. The manner in which such tests were made and the results obtained have been described by Nichols in a recent article (5). Briefly, his results showed that, with no baffling, an index of 5.0 can be expected, and that, with careful baffling, proper port velocities, proper length of tank, etc., the index can be reduced to 2.1. According to the data of these experiments, peak flow occurred at 50 per cent of the theoretical detention time when the index was 5.0, and at 95 per cent when the index was 2.1. Other tests, not reported by Nichols, show that a variation in flow of as much as 100 per cent through one unit* will change the dispersion index less than 5 per cent, if the unit is properly designed. Furthermore, tests made of units in service and of models of these units having static and dynamic similitude show hydraulic characteristics which are almost identical. The author's work has definitely shown that if models are built and operated as outlined above, the resulting hydraulic characteristics may be used with certainty to forecast the characteristics of the full-scale design.

For determining the correct dosage of coagulant, a laboratory mixer has been developed for use with liter beakers. This consists of two $\frac{1}{4} \times 3$-inch vertical arms attached to two horizontal arms 1 in. from the vertical shaft. The mixer is rotated at varying rates of speed and for time periods to approximate condition in the plant-sized unit. It has been found that 20 min. in the batch mixer gives results comparable with a 30-minute detention period in plant operation. Furthermore, quiescent settling for 20 min. and pouring off the top liquid for turbidity determination gives results similar to about 2 hr. in a continuous flow settling basin.

Flocculation Practice at Indianapolis

This type of batch control has been used at the White River Rapid Sand Filter Plant of the Indianapolis Water Co. since January 1938. The results of operation of the slow and rapid sand plants are given in Table 1. It is to be noted that, since 1938, a water of 2 ppm. average turbidity has been applied to the filters as compared with an average of 6 ppm. for the preceding ten years. Average alum consumption has been reduced from 270 to 191 lb. per mil.gal., while the flow through the plant has been increased from 2,895 to 4,212 mil.gal. per year. Also, in the previous ten years the water was retained for 6 hr. in the coagulation basins, whereas during peak flows today the water has a detention of 32 min. in the flocculating units and 1.8 hr. in the settling basin.

The Indianapolis Water Co. has recently put into operation its new Fall Creek Rapid Sand Filter Plant. This very modern and efficient plant was

* The units referred to in this discussion are those known as "Floctrols," manufactured by the Jeffrey Mfg. Co., with whom the author is associated.

designed by W. C. Mabee, Chief Engineer for the company. Its pretreatment plant design follows the experience gained in operation of the White River Plant. The plant treats water from Fall Creek and handles a maximum flow of 16 mgd. Turbidity ranges from 5 to 1,500 ppm., alkalinities from 75 to 250 ppm., and pH from 7.0 to 8.2. The pretreatment plant comprises four covered channels 260 ft. long, 16.0 ft. wide and 15.0 ft. deep, the first 62 ft. being used for flocculation and 198 ft. for settling. Each channel is designed to handle a flow of 4 mgd. Detention periods at designed flow in the flocculation and settling portion of each

TABLE 1

Operating Results at White River Filtration Plant of Indianapolis Water Company

YEAR	SLOW SAND PLANT		RAPID SAND PLANT			
	Water Treated per Year	Alum Dose	Water Treated per Year	Alum Dose	Turbidity	
					Raw	Settled
	mil.gal.	*lb. per. mil.gal.*	*mil.gal.*	*lb. per mil. gal.*	*ppm.*	*ppm.*
1928	6,112	204	2,961	201	59	9
1929	6,584	203	3,053	223	65	6
1930	6,474	153	3,313	164	36	8
1931	6,614	146	2,491	193	23	10
1932	6,558	230	2,067	249	40	7
1933	5,321	260	2,270	370	61	5
1934	5,983	284	3,114	418	21	3
1935	6,524	236	2,814	325	25	4
1936	7,300	244	3,168	318	17	2
1937	7,027	227	3,703	255	75	2
Average..	6,450	218	2,895	270	42	6
1938	7,063	256	3,729	168	46	2
1939	6,693	234	4,399	186	43	2
1940	6,575	277	4,508	218	29	2
Average..	6,777	256	4,212	191	39	2

tank are 40 min. and 2.0 hr. respectively. Instead of using a flash mixer on all the raw water, mixing is accomplished in a small chamber, called a diluter, equipped with a high speed agitator. Through this chamber, up to 5 per cent of the raw water is taken and mixed with the coagulant to form a dilute solution. The solution then passes into the disperser channel extending across the inlet end of the four flocculation sections. This channel is equipped with a paddle wheel which maintains rates of agitation about equal to those in the first compartment of each unit. All high speed mixing is done in the disperser and in the first compartment of each

unit. Sluice gates in the disperser channel make it possible to use all or a portion of the channel and thus vary the detention time to get the best results. When the plant is treating 16 mgd. the detention period in this channel varies from 30 sec. to 2 min.

Each flocculation basin is divided into five compartments, the lengths of which vary from 4 ft. 6 in. at the inlet end to 20 ft. at the outlet end. Paddle wheels, 13 ft. $8\frac{1}{2}$ in. in diameter, are mounted on horizontal axes. Two variable speed drives for each unit provide peripheral speeds of 1 to 3 fps. in the first three bays and from $\frac{1}{2}$ to $1\frac{1}{2}$ fps. in the last two bays.

A 60-foot section of each settling basin is equipped with conveyor type sludge removal equipment. It is believed that most of the sludge will settle in this length. Detention period in each basin at designed flow is 2 hr. with overflow rates of 1,330 gal. per sq.ft. per 24 hr. Three cross weirs, 17 ft. on centers, and longitudinal weirs 51 ft. long, along each side wall, have been provided to take off the effluent uniformly and with a minimum of disturbance.

During a three-week tuning-up period, 24-hour tests using about 2 gpg. alum (the correct amount as determined by standard batch procedure) have produced settled water containing about 1 ppm. During these tests the flocculation and settling tanks have been operated at the designed rate.

It is believed that the most efficient flocculation is produced by many small vortexes following the passage of narrow paddle blades through the water, rather than by the fewer larger vortexes resulting from the use of wider blades. For this reason, the standard design has included a large number of 3-inch blades as a means of agitation. Nichols (6) has recently reported that VanKarman has shown that, in straight line motion, the distance between vortexes varies directly with the width of paddle blade divided by a constant. If this follows for circular motion, it is possible that width of blades should be decreased, their number increased and speed of rotation reduced until just sufficient to prevent deposition.

Conclusions

1. Rapid mixing of coagulant with the raw water is necessary as the first step in good flocculation.

2. Coagulant should be applied to the raw water in as dilute form as possible.

3. Tapered mixing is necessary to produce the best results.

4. Short circuiting of the flow through the tank should be reduced to a minimum.

5. The tank should be subdivided into compartments, providing increased time in each succeeding step.

6. Narrow paddle blades, arranged to cover a large percentage of area agitated by the paddle wheel, are essential.

7. The area covered by paddle wheels should be not less than 65 per cent of the cross-sectional area of the basin.

8. Variable speed drive is desirable to vary paddle speeds with the changing conditions of the raw water.

9. Changes of rates of agitation in any zone should be possible by changes in the arrangement or the number of paddles used.

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Report of the Committee on Water Works Practice

HEREWITH is a report presented to the Board of Directors of the American Water Works Association at its annual meeting on January 19 and 20. A record of action taken by the Board, along the lines indicated in this report, appears in the Appendix (p. 424).

This report is a summary of the technical committee activities of the A.W.W.A. as guided by the Committee on Water Works Practice. The report also covers activities of committees of other associations, where the A.W.W.A. has an appointed representative.

The Committee on Water Works Practice now consists of fifteen members:

Malcolm Pirnie, *Chairman*	Wm. W. Hurlbut
Reeves Newsom, *Vice-Chairman*	Wendell R. LaDue
Frank A. Barbour	Dale L. Maffitt
Chas. R. Cox	Denis F. O'Brien
W. W. DeBerard	W. H. Weir
Ross L. Dobbin	W. Victor Weir
Arthur E. Gorman	Abel Wolman
Louis R. Howson	

Four men were added to the committee during 1941: Mr. Howson, representing the consulting engineering profession; Messrs. LaDue and W. V. Weir, representing the viewpoint of water works superintendents; and Mr. C. R. Cox, representing the viewpoint of state sanitary engineers. Mr. Cox is, in fact, the representative of the Water Purification Division, as its secretary. His appointment was made in line with the desire expressed by the Board, at its January 1941 meeting, that an official Representative of the Water Purification Division be appointed to the Board, in order to maintain more effective contact between the Committee on Water Works Practice and the various activities of the Water Purification Division. The Division has expressed its wish to be represented on the Water Works Practice Committee by its secretary. This has been accepted as a permanent policy.

Water Works Practice Committees

1. *Deep Wells and Deep Well Pumps.* A draft of the main body of the specifications for wells has been completed in revised form, together with approximately two-thirds of the appendixes which describe the various alternatives left open in the specifications. The committee co-chairmen have not to date received from members, to whom certain of these appendixes were assigned, the results of their work on them.

A second draft of the specifications covering pumps has been completed to the point where conferences with manufacturers are in order, to reconcile conflicting ideas on certain points. The Hydraulic Institute has offered its good offices in bringing the manufacturers together in conference with the committee.

In view of the present impossibility of getting well pump equipment on any other basis than acceptance of what is available, the chairmen of the committee question the advisability of attempting to release, for tentative use, specifications which do not meet general agreement among the manufacturers.

With reference to well specifications, however, it appears advisable to attempt to complete these at as early a date as possible, inasmuch as emergency conditions add to, rather than detract from, the number of occasions in which they may be useful.

2. *Manual of Water Quality and Treatment.* After revision of the text as first printed in 1940, 2,000 copies were printed in 1941. The text now appears generally acceptable and is being widely used as a reference document. The type of the text has been torn down.

3. *History of Water Purification.* M. N. Baker reports: "My history of water purification is nearly completed. It is in two parts: I. Chronological narrative, covering nearly 4,000 years; II. Topical treatment, in more detail, of Slow Sand Filtration; Filtration Basins and Galleries; Rapid Filtration; Upward Filtration; Multiple Filtration; Sedimentation, Coagulation; Distillation; Disinfection; Algae; Tastes and Odors; Softening; Iron and Manganese Removal; Filtration Experiments; Typhoid Reduction.

When the text is received it will be prepared for the printer.

4. *Safe Handling of Water Works Chemicals.* This committee presented, at the time of the Toronto Convention, a report on handling activated carbon. Among other things it recommended the special labeling of all packages to indicate hazards related to the material. The suggestion has been made that this recommended labeling may increase freight charges. The report will not be printed until this issue is clarified.

5. *Steel Plate Pipe.* Documents which have been advanced to *Standard* status are:

7A.4 A.W.W.A. Standard Specifications for Steel Water Pipe of Sizes of 4 inches up to but Not Including 30 Inches

7A.7 A.W.W.A. Standard Specifications for Cement-Mortar Protective Coating for Steel Water Pipe of Sizes 30 Inches and Over"

Document 7A.2, "*Tentative* Specifications for Lock-Bar Pipe" will not be made standard.

6. *Laying Cast-Iron Pipe.* No work is current in the field of this committee's activity.

7. *Valves, Sluice Gates and Fire Hydrants.*

7.1. *Valves.* No discussions are current on valves.

7.2. *Sluice Gates.* The tentative specifications for sluice gates were published in the October 1941 JOURNAL. Reprints are available. No comments upon the document have been received.

7.3. *Fire Hydrants.* Considerable discussion has arisen concerning paragraph 3.11 of the specifications which reads:

> "*Operating Mechanism.* The operating threads of the hydrant shall be designed so as to avoid the working of any iron or steel parts against other iron or steel. Either the operating stem or the operating nut shall be, or both may be, of non-corrodible metal. The operating stem and nuts shall have square, V, or Acme threads which shall be designed with a factor of safety of not less than 5 for all stresses that may occur when a wrench with a 15-inch arm is used on a hydrant subjected to water pressure of 150 pounds per square inch."

An attempt is being made to clarify the meaning of the requirement for resistance of the threads to deformation.

8. *Location Records and Maintenance of Mains and Services.* This committee has no work current.

9. *Steel Standpipes and Elevated Tanks.* This document was editorially revised and published as *Standard* in August 1941. It is now being widely used.

Considerable discussion has arisen concerning the practices of certain tank painting and maintenance firms. An official statement upon the subject is in preparation.

10. *Pipe Line Coefficients.* This committee has made no recorded progress during 1941.

11. *Distribution System Safety.* This committee's report was presented at the Toronto Convention. It has been reviewed by the Com-

mittee on Water Works Practice. Because of the fact that the proposed drinking water standard contains an appendix which is in effect a code for water distribution, it appears advisable to put the Association committee's report into print.

12. *Cross-Connections.* The report made by this committee at the Toronto Convention was published in the January 1942 issue of the JOURNAL. No further work is current.

13. *Fire Prevention and Protection.* A primer of information on this subject has been prepared by the committee and is presently being revised in the light of certain comments received.

14. *Meters.* The report on "Cold Water Meters—Displacement Type" was published in the December 1941 JOURNAL. It contains the following reference to effective date.

> "*Effective Date:* These '*Tentative* Specifications for Cold Water Meters—Displacement Type' on *January 1, 1943*, will supersede the 'Standard Specifications for Cold Water Meters—Disc Type' adopted by the A.W.W.A. June 9, 1921. They may, in the meantime, be used as a basis of purchase of water meters whenever their use is agreed to by the customer and the manufacturer."

Specifications for other types of meters are now in preparation.

15. *Service Line Materials.* The report of this committee was received by the Water Works Practice Committee at Toronto. Because of the difficult procurement situation, it has appeared inadvisable to publish this material.

16. *Committee on Survival and Retirement Experience With Water Works Facilities.* This committee is making commendable progress. The New England Water Works Association has appointed a co-operating committee consisting of Messrs. Carleton (Chairman), Fuller, Newsom, Ruggles, and Wiggin. Studies under committee direction were in progress in 33 cities on November 1, 1941. E. A. Aldrich is Supervising Co-ordinator for the committee. The Institute of Water Utilities has given substantial cash support to the work of the committee and the various cities engaged in the study have collectively assigned a large number of employees to the work in progress.

Water Purification Division Committees

17. *Co-ordination of Methods of Water Treatment and Laboratory Control.* This committee has developed several annual summaries of the prevalence of water-borne outbreaks in the United States and Canada. The Water Purification Division considers that the groundwork for such annual study has been laid by the committee and that future summaries can be developed as a staff project. The committee has been discharged.

18. *Specifications and Tests for Water Purification Chemicals.* This project has not been completed. Following action by this Board in January 1941, the chairman of the committee was requested to forward the material to the office of the Association for editing and publication. A request was made by him that he be permitted to carry on to the end of the year when it was hoped the work could be finished. Demands upon his time have been so heavy that the work could not be done. It is anticipated that the material will shortly be available for staff handling.

19. *Activated Carbon Research.* This committee was dissolved by action of the Water Purification Division at Toronto. No completed work was in hand. This committee developed a very fine specifications and test document which was published in 1938. The committee is greatly to be commended for this contribution to the field.

20. *Specifications for and Methods of Testing Zeolites.* This committee is now drawing together the various comments made on the first report and will shortly file a final report. This is a valuable activity and the report will serve a major need in the field.

21. *Methods of Determining Fluorides.* This committee has finished its work and has been discharged. Its final report was published in the November 1941 JOURNAL.

22. *Chloramination.* This committee's work is completed and the report was published in the December 1941 JOURNAL.

23. *Water Conditioning Methods to Inhibit Corrosion.* The committee under the chairmanship of Professor E. W. Moore presented a progress report at Toronto which has been published. A report on corrosion inhibition by use of metaphosphates is in preparation.

24. *Standards for Purification Plant Operation.* This committee presented a report at Toronto. The report was accepted and the committee discharged. The document was ordered made available to the various sections for study and comment. This has been done. The comments will be considered by the Water Purification Division at the next annual meeting.

25. *Specifications for Filtering Material.* A second progress report has been filed by the committee chairman. It is, in effect, a set of specifications for filtering material. This has been greatly needed as an Association standard specification.

26. *Permissible Loadings and Capacities of Water Treatment Plants.* This committee has been reorganized and gives promise of producing useful data during the year.

27. *Methods of Determining Residual Chlorine.* The Water Purification Division has set up a committee to prepare the precise text of procedures proper for determination of residual chlorine. C. K. Calvert is Chairman. The committee definitely plans to report at the 1942 annual meeting.

Finance and Accounting Division Committees

28. *Joint Administration and Collection of Water and Sewer Accounts.* This committee presented a report at the 1941 convention. The report has been published. The suggestion has been made that an inter-association committee be set up to carry on this work. It is not clear that there is a field for such committee.

29. *Lien Laws.* The chairman of this committee, H. L. Meites, has committed himself to presentation of a definite report at the 1942 meeting.

Joint Committees With Other Organizations

30. *Joint Editorial Committee on Standard Methods for the Examination of Water and Sewage.* The ninth edition of *Standard Methods* is now scheduled for publication late in 1943. The A.W.W.A. representatives on this committee are: Wm. D. Hatfield, H. A. Leverin, and M. C. Schwartz.

31. *Joint Research Committee on Boiler Feed Water Studies.* The embrittlement studies, which have been in progress for several years, appear to have been carried as far as committee work makes possible. The findings of the committee have received wide but not universal acceptance. Consideration is now being given to the initiation of a research program related to silica in boiler waters. This is a problem of importance and is within the proper field of activity of the committee.

32. *American Co-ordinating Committee on Corrosion.* This committee continues to act as a clearing house of information on its subject. The work is valuable and should be continued.

33. *Joint Committee on Construction Contracts.* The war has compelled this committee to put aside its task of revising the standard form of construction contracts.

34. *American Research Committee on Grounding.* The Joint Research Committee report for 1941 was printed in the January 1942 JOURNAL.

The Association's research project at New York University is under way. Professor Eliassen has issued the following statement:

"The $\frac{3}{4}$-inch pipes for testing purposes have been purchased from various distributors where available. Three 21-foot lengths of galvanized pipe were obtained from the same stock, as were the three 21-foot lengths of red brass pipe. The lead and copper pipes were purchased in 60-foot coils on the open market. Analyses of the compositions of the respective pipes are being made by the Metallurgical Department of the University. The twelve pipes were hung in a vertical bank, all connected to a transite header in the basement of the Sanitary Engineering Research Laboratory as outlined in the report to the Convention on June 26, 1941.

"Electrical equipment consisting of transformers, rectifiers, batteries,

resistors and switches were assembled after a great deal of searching the many electrical stores in the city. The circuits were arranged according to the suggestions of the members of the Technical Sub-Committee of the American Research Committee on Grounding. Experiments were first conducted using various items of equipment borrowed from the Electrical Engineering Department of the University. These were made to determine the current, voltage and other characteristics of the rectifiers, transformers' and resistors in order to give the desired a-c. and d-c. over the pipes. The final installation is satisfactory in all respects and is ready to operate.

"For the purpose of polarographic analysis, the University purchased a Fisher Elecdropode. This instrument has been calibrated by the Research Fellow and is now being used to analyze the samples of water drawn from the pipes. Water has been running through the pipes since November 20 at a rate giving a detention of 8 min., after which the water is wasted. This is being done in order to season the pipes as they would be in a household. No current has been applied as yet but will be shortly.

"On December 15, Messrs. Cole, Kent, Meyerherm, Spence and Walquist of the Technical Sub-Committee of the American Research Committee on Grounding inspected the set-up of equipment and went over the experimental procedure. They expressed themselves as being pleased with the apparatus and the progress of the work. They outlined the procedure for the test runs on which work has now been started.

"The procedure calls for measurements of metallic ion concentrations of the water entering and leaving each pipe, varying the detention time of water in the pipe, and determining when stabilization is reached by similarity of effluents from each of three pipes of the same composition. Then the current will be turned on for comparative observations."

35. *Water Works Terms.* This work has not progressed materially during 1941.

36. *Water Works Accounting Manual.* The committee does not consider that revision of the text is yet indicated.

37. *Joint Committee on Water Hammer.* No work is in progress.

A.W.W.A. Representatives on Committees of Other Organizations

U. S. Bureau of Standards

38. *Simplified Practice Committees on Wrought Iron and Wrought Steel Pipe, Valves and Fittings.* Sheppard T. Powell who has served as A.W.W.A. representative on this Bureau of Standards Committee has asked to be relieved. The appointment of H. Arthur Price of Los Angeles is recorded. Mr. Price represents the A.W.W.A. on A.S.A. Committee B31, a similar project. The committee is active at present.

American Standards Association

39. *Specifications for Cast-Iron Pipe and Special Castings.* No portion of the pending work of this committee has been completed during 1941.

40. *Manhole Frames and Covers.* This project is now complete and approved as an A.S.A. standard. The report awaits publication. F. A. Marston, A.W.W.A. representative on the committee reports:

"The proposed 'American Standards for Manhole Frames and Covers' comprise specifications covering the design, materials and dimensions of manhole frames and covers for sub-surface structures, except those used for electric supply and/or gas services. The designs include thirteen types of cast-iron manhole frames varying in size of opening from 22 to 42 in., five types of cast-iron covers of corresponding sizes, and two types of cast-steel covers for 36- and 42-inch frames."

41. *Standardization of Plumbing Equipment.* After an extended discussion, it has been recommended by the A.S.M.E. that the American Public Health Association be made joint sponsor of this committee. This will bring the public health viewpoint fully into the work.

It is recommended that when the A.P.H.A. becomes joint sponsor, the A.W.W.A. appoint a representative to Sub-Committee 1. This committee is now engaged in preparation of a standard plumbing code.

42. *Pipe Thread.* W. W. Brush, who represents the A.W.W.A. on this committee reports as follows:

"Under date of November 21, 1941, I was advised by C. B. LePage, Secretary, Section Committee on the Standardization of Pipe Thread B2, that a corrected copy of the proposed revision of the "American Standard for Pipe Thread," dated October 1941, had been forwarded to the A.G.A. and the A.S.M.E., the joint sponsors of this project, for approval and transmission to the A.S.A. These proposed specifications, which cover 19 pages, apply to taper and straight pipe thread, but do not apply to the underground fittings which are of the most interest to the water works field.

"I recently wrote to Edward S. Cornell Jr., 17 Campbell Lane, Larchmont, N.Y., who was formerly an engineer with the American Radiator Co., and who had done a great deal of the work of preparing standards for threads for corporation stops, curb stops, and other underground fittings. He states that in his opinion, 'the work already done on the standards for water works fittings indicates a special use and condition, and I feel that reactivation of the committee, enlarged to bring into the conferences manufacturers concerned, would be the most constructive way of having this standard adopted.'

"As far as I know, there has been no work done for a number of years by Committee B2 on the thread standardization work that the water works field is mainly interested in. It seems that progress would probably be

best made if A.W.W.A. sets up a committee to undertake the standardization of threads for underground water works fittings, inviting other water works organizations to join in the setting up of such a standard."

43. *Pipe Flanges and Fittings.* The A.W.W.A. representatives, Messrs. Barbour and Hurlbut, report as follows:

"New standard specification on cast-iron screwed drainage fittings has been approved by the sectional committee and sponsor bodies and was submitted November 28, 1941, to the American Standards Association.

"The proposed standard specifications for 'Steel Socket-Welding Fittings' have been completed.

"Certain studies are being made of American Standards Association Standard Specification B16e, "American Standard for Steel Pipe Flanges and Flanged Fittings," with regard to the present rating tables, flanged facings, bolted joints and review of the welding end situation.

"The 'American Standard for 125- and 250-pound-Cast-Iron Screwed Fittings' was transmitted to the American Standards Association in December 1940 and received its approval in March 1941.

44. *Code for Pressure Piping.* The A.W.W.A. representative, H. Arthur Price, reports as follows:

"The 'American Tentative Standard Code for Pressure Pipe' has been completed by various sub-committees and reviewed by the Editing Committee and is now in the hands of the members of the sectional committees for review. In the reorganization of the sub-committees, a new sub-committee on refrigeration piping was added. The second edition will consist of the following sections:

Sec. 1. Power Piping Systems
Sec. 2. Gas Air Piping Systems
Sec. 3. Oil Piping Systems
Sec. 4. District Heating Piping Systems
Sec. 5. Refrigeration Piping Systems
Sec. 6. Fabrication Details"

45. *National Electrical Code.* The last edition of the code was published in 1940 and certain revisions are now under consideration for the 1943 edition.

46. *Standardization of Dimensions and Materials of Wrought-Iron and Wrought-Steel Pipe and Tubing.* The A.W.W.A. representative, H. Arthur Price, reports as follows:

"The three following specifications which were approved by the American Standards Association as American Standards on the recommendation of Sectional Committee B-36 were revised at the annual meeting of the American Society for Testing Materials in June 1941:

Welded and Seamless Steel Pipe (A.S.T.M. A53–40; A.S.A. B36.1—1940)

Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A.S.T.M. A106–40; A.S.A. B36.3—1940)

Electric-Resistance-Welded Steel Pipe (A.S.T.M. A135–34; A.S.A. B36.5—1935)

"The revision of the specifications for 'Lap-Welded and Seamless Steel Pipe' was completed during 1941."

47. *Specifications for Zinc Coating of Iron and Steel.* Sheppard T. Powell, A.W.W.A. representative has resigned and Paul Weir has been appointed to represent the Association on this committee.

48. *Letter Symbols and Abbreviations for Science and Engineering.* Mr. Richard Hazen has just been appointed to represent the A.W.W.A. on this committee. A report on letter symbols for hydraulics is now awaiting approval. Considerable dissent concerning details of the report has been expressed. It may not, however, be possible to delay action upon the report until certain issues are clarified.

49. *Specifications for Sieves for Testing Purposes.* No work in progress.

50. *Standardization of Graphical Symbols for Use on Drawings.* W. V. Weir, representing the A.W.W.A., reports that the text of Standard Graphical Symbols for use in Mechanical Engineering has been given A.S.A. approval. (The report was published (in part) in the February JOURNAL since it contains much material of interest to water works men.)

National Fire Protection Association

51. *Forests.* No activity.

52. *Hydrants, Valves and Pipe Fittings.* F. A. Barbour transmits the following report made by A. L. Brown, Chairman of this committee:

"For two years or more the Committee on Hydrants has been reporting to this Association upon progress in the development of consistent specifications for fire hydrants which would serve the needs of the American Water Works Association and the N.F.P.A., especially those members of the N.F.P.A. who have responsibility for approving or otherwise certifying to the quality of fire protection equipment. An important step toward the final accomplishment of this unification was the preparation and the publication in September 1940 of the new A.W.W.A. 'Standard Specifications for Fire Hydrants for Ordinary Water Works Service.' These specifications were made effective for purchases after November 1, 1940.

"It should be pointed out that the A.W.W.A. specifications cover the various types and classes of hydrants for general water works service, while the N.F.P.A. specifications are for hydrants to be used in private

fire service. Consequently it has not been feasible and it is not essential to make a single specification for both services. Efforts have been directed mostly toward the elimination of conflict, so that manufacturing and testing can be simplified, and common features covered by uniform requirements.

"A few remaining differences in the specifications, which have been the subject of considerable discussion, and a few which were of particular significance in relation to private fire service, have been adjusted by your committee during the period of this annual meeting, so that now they can be mentioned briefly and a complete new draft of the N.F.P.A. specifications prepared in readiness for presentation at the next annual meeting of the Association. Because this specification is of greatest importance to a relatively small number of manufacturers and to approving laboratories, this delay will not be of serious consequence.

"For the information of the N.F.P.A. the following decisions have been reached by your committee with regard to the features in which the N.F.P.A. specifications have differed from the new A.W.W.A. specifications.

"(1) The N.F.P.A. specifications will include a statement which is not appropriate in the A.W.W.A. specifications, that: 'Hydrants for Private Fire Service should not have Fire Department pumper nozzles unless they are called for by the inspection department having jurisdiction.'

"(2) Independent gates on hose outlets may be required by the inspection department having jurisdiction.

"(3) The N.F.P.A. specification for a minimum 5-inch diameter valve opening for two-way hydrants will no longer be included, it being considered that the purpose of this requirement will be adequately accomplished by the friction loss limitations.

"(4) The allowances for friction loss in the N.F.P.A. specifications will be increased moderately to bring them into agreement with the values established by the A.W.W.A.

"(5) The fastening of hose nozzles to the hydrant barrel by leading will be allowed, but a preference will be stated for nozzles attached by threading and pinning.

"(6) An uncertainty remains regarding the interpretation of the A.W.W.A. specifications covering the strength of the hydrant operating stem. A final decision depending upon this awaits the outcome of discussions with the A.W.W.A."

53. *Public Water Supplies for Private Fire Protection.* No activity.

54. *Tanks.* L. R. Howson, A.W.W.A. representative on this committee, reports as follows:

"The N.F.P.A. committee has completed the September 1941 edition of 'Standards for Gravity and Pressure Tanks' (last previous edition, 1931). Revisions relate largely to welding and details of design.

Miscellaneous Committees

55. *Inspection of Welded Structures.* The Association has appointed a representative (R. C. Kennedy) on this American Welding Society Committee. Specifications are now in preparation. This work is important.

56. *U. S. Public Health Service Standards for Drinking Water for Use on Interstate Carriers.* The second draft of the proposed revision of the 1925 Standard is under consideration. The Advisory Committee includes C. R. Cox as representative of the A.W.W.A. A full discussion of the proposed revision was had at the Toronto Convention and has since been published in the JOURNAL.

57. The following committees upon which the Association is represented are not active

A.S.M.E. Pumps (S. M. Dunn, Representative)
A.S.T.M. Sulfur Cement (J. P. Schwada, Representative)
New York City Health Department Advisory Committee (Thos. M. Riddick, Representative)
N.A.R.U.C. Committee on Classification of Accounts (L.D. Blum, Representative)

American Standards Association Activities

The Association is represented on the A.S.A. Council by Harry E. Jordan. Richard Hazen has been appointed as alternate.

The Association's representative on the A.S.A. Council is at present opposing the adoption, as A.S.A. standards, of three A.S.T.M. documents:

Methods of Testing Lime
Methods of Expressing Results of Water Analyses
Specifications for Spiral Welded Steel Pipe

No issue is taken with these documents as A.S.T.M. Specifications, but they will, if approved as A.S.A. standards, conflict with A.W.W.A. documents either in preparation or already promulgated. It is, therefore, suggested that the request for A.S.A. approval be withdrawn.

Emergency Conditions Affecting Specifications

The Office of Production Management has asked for A.W.W.A. representatives on committees to simplify, for the war period, specifications for well tubing and steel water pipe. Names of A.W.W.A. members have been submitted. If these persons are requested to serve by the

O.P.M., it is expected that they will present the water works viewpoint adequately.

Some months ago, the Board was asked to approve a method of making exceptions to A.W.W.A. specifications when, under war conditions, the specified materials were not obtainable. Considerable objection to the suggested method was made. It is, therefore, suggested that, for the duration of the emergency, whenever a manufacturer, receiving a request to furnish material according to A.W.W.A. specifications, is unable to obtain one or more standard items, he advise the purchaser by letter precisely what substitutions he proposes to make. Upon acceptance of the substitute items by the purchaser, the manufacturer may proceed to fill the order. A written record of the exceptions to the specification is an essential part of the procedure and must not be overlooked.

New Committee Work

The Committee on Recommended Design for Valve Boxes and Covers, Curb Stop Boxes and Covers, and Meter Boxes and Covers is now being organized with Frank A. Amsbary as Chairman. Consideration can be given to setting up a committee on threads for corporation stops and curb stops. The revised specifications for meters contain a stipulation for a standard thread for meter connections.

Respectfully submitted,

MALCOLM PIRNIE, *Chairman*

Appendix—Action by the Board

Following presentation of the above report, the following action was taken by the Board of Directors:

The Water Works Practice Committee was authorized to approve an interpretative note to be added to the hydrant specifications to clarify the meaning of paragraph 3.11 of that document.

The appointment of a representative of the A.W.W.A. to the code subcommittee of A.S.A. Committee A40, whenever the A.P.H.A. has been made a co-sponsor of the project, was authorized.

A committee on "Threads for Water Service Line Fittings" was authorized.

The Secretary was directed to prepare an official statement of the Board's attitude concerning sharp practices among concerns engaged in the painting and repair of elevated tanks.

The Board took notice of the fact that, as a result of the wartime emergency, manufacturers of water works equipment would not be able to obtain

all materials required to produce equipment in accordance with A.W.W.A. specifications. It was, therefore, agreed that:

> Whenever a manufacturer is requested to furnish equipment or materials in accordance with A.W.W.A. specifications and is unable to fill the order precisely in accordance with such specifications because of restrictions upon the use of critical materials, he shall advise the purchaser, in writing, that certain designated substitutions must be made if the order is to be filled. The purchaser shall, likewise in writing, submit his acceptance of the modification of the specifications before the manufacturer proceeds with the order. The above procedure is not intended to be a blanket suspension of specification details, but is intended to be a part of the negotiations between the manufacturer and purchaser, when exceptions must be made to standard specifications.

The Board took notice of A.S.A. procedure as it relates to approval of standards prepared by a constituent association affiliated with the A.S.A., where the control of future revisions of the standards is granted on a proprietary basis to the association which first prepared them. The Board agreed that:

> The assignment of proprietary sponsorship for specifications approved by the A.S.A. is an action which should be undertaken with reserve and only when it is shown that no other constituent body within the A.S.A. has already developed or has in preparation standards or specifications which parallel those submitted for A.S.A. approval.

HARRY E. JORDAN, *Secretary*

Report of the Audit of Association Funds For the Year Ending December 31, 1941

To the Members of the American Water Works Association:

The By-Laws require that the Secretary shall have made an annual audit of the books of the Association.

The records for 1941 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Reference may be made to past audits which appeared in the JOURNAL as follows: pp. 520–25, March 1938; pp. 570–74, March 1939; pp. 516–20, March 1940; and pp. 774–78, April 1941.

There is also submitted a membership statement for 1941 and a comparative record for 1932–41 inclusive.

Respectfully submitted,
HARRY E. JORDAN, *Secretary*

February 16, 1942

Mr. Harry E. Jordan, Secretary
American Water Works Association
22 East 40th Street
New York City

DEAR SIR:

We have examined the balance sheet of the American Water Works Association, as of December 31, 1941, and the statement of income and expenses for the year ending December 31, 1941, have reviewed the system of internal control and the accounting procedures of the Association and, without making a detailed audit of the transactions, have examined or tested accounting records of the Association and other supporting evidence, by methods and to the extent we deemed appropriate.

In our opinion, the accompanying balance sheet and related statement of income and expenses present fairly the position of the American Water Works Association at December 31, 1941, and the results of its operations for the year ended at that date, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

Very truly yours,
LOUIS D. BLUM & CO.
Certified Public Accountants

EXHIBIT A—Balance Sheet, December 31, 1941

Assets

Cash in Banks and on Hand			$20,800.86*
Deposit—United Air Lines			425.00
Accounts Receivable:			
Advertising		$2,117.50	
American Public Health Association		882.30	
Reprints		243.97	
Sundry publications		643.34	3,887.11
Membership Dues			227.83
Accrued Interest on Bonds			293.11
Inventories:			
Type metal		$352.44	
Journal paper stock		3,373.66	
Manual of Water Quality and Treatment (445 copies)		667.50	
Cumulative Index (419 copies)		556.80	
Manual of Water Works Accounting (28 copies)		40.60	
Sundry publications		590.79	
Membership certificates		19.35	
Fuller Memorial Award certificates		51.75	
Back issues—Journal—Vols. 1 to 33, inclusive (22,051 copies)		—†	
Back issues—Proceedings—1881 to 1926, inclusive (324 copies)		—†	5,652.89
Office Equipment:			
Depreciated balance, January 1, 1941	$3,828.04		
Net additions for year 1941	387.72	$4,215.76	
Less: Depreciation for year 1941		478.23	3,737.53
Investments, per Schedule 1:			
Investments at cost		$56,221.11	
Excess of redemption value of United States Savings Bonds over issue price		1,660.00	57,881.11
1942 Convention Expenses			231.56
Total Assets			$93,137.00

Liabilities and Surplus

Accounts Payable	$179.77
Membership Dues—Advance Payments	13,581.82
Unearned Subscriptions to Journal	977.70
Reserve for Award Fund (McCord)	154.56
Reserve for Expenses of Carbon Research Committee	48.46
Surplus, per Exhibit C	*78,194.69
Total Liabilities and Surplus	$93,137.00

* Canadian funds in the Bank of Montreal as at December 31, 1941 amounted to $2,162.63, which, if converted into U.S. currency at that date, would have resulted in a loss of $265.59. Had this loss been recorded, the cash in banks and the surplus would have been decreased correspondingly.

† Back issues of Journal and Proceedings are inventoried but no money values are assigned to them for balance sheet purposes, inasmuch as the entire costs were charged off during the years of publication.

EXHIBIT A, SCHEDULE 1—INVESTMENTS, DECEMBER 31, 1941

SECURITY		PRINCIPAL AMOUNT	DATE OF MATURITY	PURCHASE PRICE
Alabama Power Co.	4½s	$2,000.00	1967	$1,932.50
City of Los Angeles, Water Works Bonds	3½s	2,000.00	1960	2,241.11
International Tel. & Tel.	5s	3,000.00	1955	2,895.00
Province of Ontario	4½s	2,000.00	1946	1,690.00
Province of Ontario	4s	1,000.00	1964	732.50
Province of Ontario	5s	3,000.00	1942	3,105.00
Province of British Columbia	4½s	1,000.00	1951	1,000.00
Southern Pacific	4½s	5,000.00	1977	4,875.00
United States Savings Bonds (Issue price)		5,250.00*	1947	5,250.00
United States Savings Bonds (Issue price)		7,500.00†	1948	7,500.00
United States Savings Bonds (Issue price)		7,500.00‡	1949	7,500.00
United States Savings Bonds (Issue price)		7,500.00§	1950	7,500.00
United States Savings Bonds—Defense Series G		10,000.00‖	1953	10,000.00
Total Securities		$56,750.00		$56,221.11
Excess of Redemption value of United States Savings Bonds over issue price to December 31, 1941				1,660.00
Total Investments				$57,881.11

* Maturity value at May 1, 1947—$7,000.00.
† Maturity value at December 1, 1948—$10,000.00.
‡ Maturity value at March 1, 1949—$10,000.00.
§ Maturity value at January 1, 1950—$10,000.00.
‖ Maturity value at September 1, 1953—$10,000.00 (Redemption value at March 1, 1942—$9,800.00).

EXHIBIT B—STATEMENT OF INCOME AND EXPENSES FOR THE YEAR ENDED DECEMBER 31, 1941

Operating Income:		
Annual dues	$42,907.97	
Advertising	27,977.50	
Subscriptions to Journal	2,811.01	
Convention registration fees	6,114.00	
Convention—All-Section Dinner	1,320.00	
Convention extra tickets	464.50	
Water and Sewage Works Manufacturers Assn.	7,500.00	
Interest on investments*	1,652.07	
John M. Goodell prize	75.00	
Miscellaneous interest income	9.22	
Total Operating Income		$90,831.27
Publication Income:		
Sales of Manual of Water Quality and Treatment	$1,712.96	
Sales of Manual of Water Works Practice	65.00	
Royalties on Manual of Water Works Practice	11.50	
Sales of Manual of Water Works Accounting	242.65	
Sales of Reprints	1,877.06	
Sales of Cumulative Index	294.44	
Sales of membership certificates	28.40	
Sales of Proceedings and Journals	683.12	
One-half of profits from sales of 8th edition of Standard Methods of Water Analysis	882.30	
Sales of specifications—miscellaneous	99.30	
Sales of specifications—cast-iron pipe	512.04	
Sales of specifications—steel pipe	428.54	
Sales of specifications—elevated steel tanks	902.06	
Sales of specifications—gate valves	18.35	
Sales of specifications—fire hydrants	179.79	
Sales of specifications—sluice gates	1.05	
Total Publication Income		7,938.56
Total Income (carried forward)		$98,769.83

* This account includes $740.00, which represents the increment in redemption value on United States Savings Bonds for the year 1941.

Total Income (brought forward)			$98,769.83
Operating Expenses:			
Directors' and Executive Committee Meetings:			
Travel expense	$2,616.11		
Stenographic expense	112.50		
Executive Committee expense	32.35	$2,760.96	
Administrative Expense:			
Rent	$3,000.00		
Office supplies and services	4,577.41		
Membership promotion	538.93		
General travel expense	78.66		
Auditing expense	302.05	8,497.05	
Administrative Salaries:		29,166.53	
Committee Expense		555.68	
Division and Section Expense:			
Division expense	$184.56		
Section—membership allotment	5,481.31		
Section—official travel	2,342.92		
Section—general expense	207.87	8,216.66	
Journal:			
Printing	$24,112.20		
Abstractors	586.84		
Storage—Journal paper stock	188.00	24,887.04	
Convention:			
General	$2,191.79		
Entertainment	5,893.55		
Management Committee	241.29		
Publicity	403.67	8,730.30	
Membership Dues in Other Associations		575.00	
John M. Goodell Prize		75.00	
Fuller Memorial Award		17.25	
Depreciation of Office Equipment		478.23	
Miscellaneous Expense		154.75	
Total Operating Expenses		$84,114.45	
Cost of Publications Sold:			
Manual of Water Quality and Treatment	$1,124.28		
Manual of Water Works Practice	49.26		
Manual of Water Works Accounting	149.25		
Reprints	1,677.20		
Cumulative Index	288.77		
Membership certificates, including lettering and mailing	24.95		
Journals and Proceedings	7.00		
Specifications:			
Cast-iron pipe	332.68		
Steel pipe	354.64		
Elevated steel tanks	836.51		
Gate valves	22.38		
Fire hydrants	155.91		
Sluice gates	.70		
Total Cost of Publications Sold		5,023.53	
Defense Committee		2,022.61	
Development Expenses:			
Research—electric grounding	$1,530.71		
Research—depreciation—water works structures	875.09		
Total Development Expenses		2,405.80	
Total Expenses			93,566.39
Net Income for the Year (Transferred to Exhibit C)			$5,203.44

EXHIBIT C—SURPLUS ACCOUNT FOR THE YEAR ENDED DECEMBER 31, 1941

Balance, January 1, 1941	$72,991.25
Add: Net income for the year, per Exhibit B	5,203.44
Balance, December 31, 1941, per Exhibit A	$78,194.69

Membership Statement for the Year 1941

	ACTIVE	CORPORATE	ASSOCIATE	HONORARY	JUNIOR	AFFILIATE	TOTAL
Total, January 1, 1941	3,308	317	204	25	25	78	3,957
Changes in membership grades	+6	−1	+1	+2	−8	—	—
	3,314	316	205	27	17	78	3,957
Gains:							
New Members	392	35	16	1	9	27	480
Reinstatements	81	5	4	—	—	2	92
	3,787	356	225	28	26	107	4,529
Losses:							
Resignations and Deaths	102	4	6	—	2	2	116
Dropped for non-payment of dues	212	7	3	—	4	10	236
Total, December 31, 1941	3,478	345	216	28	20	95	4,177
Total, January 1, 1941	3,308	317	204	25	25	78	3,957
Gain in 1941	165	28	12	3	−5	17	220

Comparative Statement—Gains and Losses—Ten-Year Period

YEAR	NEW	REINSTATED	RESIGNATIONS AND DEATHS	SUSPENDED FOR NON-PAYMENT OF DUES	GAIN OR LOSS	TOTAL MEMBERS AT END OF YEAR
1932	117	22	169	297	−327	2390
1933	168	56	159	234	−169	2221
1934	271	66	86	122	+129	2350
1935	565	42	85	190	+332	2682
1936	311	53	104	218	+42	2724
1937	515	86	122	139	+340	3064
1938	520	59	144	140	+295	3359
1939	578	64	112	179	+351	3710
1940	514	58	113	212	+247	3957
1941	480	92	116	236	+220	4177
Total	4,039	598	1,210	1,967	+1,460	—

ABSTRACTS OF WATER WORKS LITERATURE

Key. 31: 481 (Mar. '39) indicates volume 31, page 481, issue dated March 1939. If the publication is paged by issues, **31:** 3: 481, (Mar. '39) indicates volume 31, number 3, page 481. Initials following an abstract indicate reproduction, by permission, from periodicals as follows: *B. H.—Bulletin of Hygiene (British); C. A.—Chemical Abstracts; P. H. E. A.—Public Health Engineering Abstracts; W. P. R.—Water Pollution Research (British); I. M.—Institute of Metals (British).*

DEFENSE

Conserving Municipal Motor Equipment and Tires. Munic. Finance Officers Assn. Spec. Publication (Feb. '42). *Excerpts.*

[EDITOR'S NOTE: This article merits the particular attention of water works men, since the maintenance work for which most of their automotive is used has increased in importance almost directly with the seriousness of the emergency that has made conservation necessary.]

The Problem

"Automobile and tire rationing require immediate action by local and state governments. Three distinct problems are presented:

"1. Tires must be saved because of the rubber shortage.

"2. Automotive equipment must be handled in such a way that sufficient cars will be available and a reserve established.

"3. Where privately owned cars are being used on public business, the employees may not be able to purchase tires for such private cars. The substitution of publicly owned cars or the use of other means of transportation will be necessary in many cases.

"The first steps, then, to be taken are: (1) every possible effort to curtail mileage, (2) rigid control over the use of motor equipment, the pooling of cars, and a thorough study of ordinary and emergency needs, and (3) immediate steps to *purchase new cars* for those employees who are using private cars, where the duties of such employees entitle the city to purchase cars under rationing regulations.

What Is Being Done

"All cities over 100,000 population were asked by the Municipal Finance Officers Association to tell what steps they had taken to conserve motor equipment. The actions reported here were taken prior to February 7, 1942. Many actions, which other public bodies may follow, are recorded here.

"1. Motor equipment is housed at night in municipal garages. Cars formerly taken home at night by employees are now left overnight at central municipal garages or storage lots. The cars can thus be guarded, regularly serviced and mileage reduced.

"2. An exception to central storage may be made in vulnerable areas, where the cars may be dispersed to prevent wholesale destruction and to be available in case of emergency.

"3. Cities which did not have proper records of motor equipment are immediately taking inventories to discover the use, age and condition of equipment.

"4. Cars formerly used part time are being pooled and cars formerly used by one individual are placed in the pool and assigned as needed.

"5. Some cars are being taken out of service, stripped of tires and placed in reserve to replace cars that will soon be worn out.

"6. The routes and schedules of garbage and street cleaning trucks and other vehicles are being altered to reduce mileage to a minimum.

"7. Where employees work in a limited area, such as some health, welfare or inspection employees, or where employees work only in a limited downtown area, transportation by bus or street car is being substituted for individual automobiles.

"8. Where some employees are using privately owned cars, and others were using publicly owned cars on jobs where cars were not as essential, the publicly owned cars are reassigned to employees who were using privately owned cars.

"9. Less cruising by police cars will bring substantial saving. At least one city now stations radio police patrol cars at fire stations where they await calls.

"10. One car may be used to serve two employees; one using it in the morning and another in the afternoon.

"11. Additional storage space has been acquired by several cities to permit central storage and service of cars formerly driven home at night by employees.

"12. Cities have extended the personnel and equipment necessary to repair and maintain the cars which would normally be traded in but must now be operated for a longer period.

"13. Periodic inspection of tires, batteries and equipment is now being made regularly where this was not formerly the practice.

"14. Spare tires have been stripped off all equipment in some cities (except on certain emergency equipment such as ambulances). A pool of tires is thus established and employees whose cars have 'flats' are given the use of a central tire changing service.

"15. Employees are being instructed by meetings and by written instructions on proper methods of prolonging the life of motor equipment.

"16. The department heads are called together to discuss new regulations and make suggestions for savings.

"17. Many cities have established a small board of city officials to survey motor equipment uses, determine what cars are essential and assign equipment to the most vital spots.

General Observations

Some general observations may be made from the data submitted:

"1. Cities with central motor equipment bureaus and central garages have been able to meet the motor equipment problem most readily.

"2. A few cities report they are 'doing business as usual' and have made no changes.

"3. The cities where a substantial number of employees use their own cars on a rental basis will need to consider at once the purchase of new cars for those persons using their own private cars on vital services.

"4. Definite written regulations, followed up by the closest kind of supervision and inspection will be required really to accomplish anything worthwhile in the way of tire savings and automotive conservation.

"5. The larger municipalities have, on the whole, taken immediate and drastic action to conserve tires, save gasoline, and extend the life of their motor vehicles.

Some Suggestions for Action

"1. Immediate action is necessary. Municipalities that continue to do 'business as usual' will encounter difficulties.

"2. Most cities have inventories of their motor equipment. Other cities should immediately find out the number, condition and use of equipment including privately owned cars.

"3. Strict control should be established at once over the use of all automobiles; centralized storage is desirable except in vulnerable areas; cars should usually be taken home at night only for emergency purposes.

"4. Privately owned cars used on public business present a special problem. In some cases, where individuals, such as doctors and nurses, may be able to buy tires and possibly new cars,

they might continue to use personal cars and relieve other equipment. On the other hand, new cars should be purchased on priority ratings for persons vitally in need of cars, who cannot continue the use of private cars.

"5. The routes of garbage and street trucks may be rearranged and schedules may be changed to reduce mileage.

"6. Where their territory is compact and distances between stops is short, street car, bus, or bicycle transportation may be substituted for automobiles used by some employees.

"7. Careful and regular inspection should be made of tires, oil, grease and motors.

"8. Cars may be pooled and assigned to individuals as needed."

Bristol Civil Defense: Repairs to Water Services. R. W. MELVIN. *Excerpts from a series of talks given at a recent meeting of the Southern District of the British Inst. of Munic. & County Engrs.* Wtr. & Wtr. Eng. (Br.) **44:** 29 (Feb. '42).

[Editor's Note: Bristol, a city of approximately 400,000 population, is an important British seaport subject to frequent air attack.]

"The distribution system is complicated, as our levels vary from 25 to 370 ft. O.D. [above sea-level] and there are three main zones of pressure.

"*A.R.P. Standby.* All the Bristol water works' staff have been trained for A.R.P. duty in one way or another. We had to develop our standby after experience of several raids. At present we maintain a principal standby at water works control, and, in addition, subsidiary depots, besides turncocks at principal fire stations. Thus, each night we have on duty standby men plus an engineer, general foreman, telephone officer and assistant, and a liaison officer at A.R.P. control.

"In addition, an engineer and general foreman are on standby duty at home, and principal turncocks are all on the telephone. We were able to get some men back from the Army for duty at the fire stations. All men come to work the day following their night shift. Each of our depots has transport and decontamination equipment and we have our own decontamination station, reserve water works control, offices, etc.

"*Communications.* Our depots are equipped with national telephones, and other devices which give warning of burst mains, etc. There is also communication from water works control to the fire service control, where a fire service water officer is stationed. The latter has five divisional assistants in the city. We are thus able to keep good contact with the fire service regarding position of fires, water pressures, alternative supplies, etc.

"We maintain a water works squad of six motorcyclist dispatch riders as a precaution against the possibility of the telephones failing. One rider is always on duty at night.

"The water officer at A.R.P. control puts through to water works control all the messages affecting the water works. The A.R.P. control has been a wonderful success as far as we are concerned.

"During a raid 95 per cent of the messages received at water works control have been from A.R.P. control, the rest coming from the police, general public, etc. Of these messages from A.R.P. control, 80 per cent of them reporting burst mains have actually proved to be correct, the rest being broken service pipes, sprinklers, etc.

"It is true to say that the success of A.R.P. control has been one of the outstanding features of the civil defense in this city.

"*Function of Water Works Control.* The main job is to sift out the reports and attend to them in correct order.

"The blitz on November 24, 1940, was the first real experience of heavy raiding. A great many mains in the city were then damaged, including several trunk mains, and the general city pressure was low. Even had there been no burst mains, it is safe to assume that the pressure would have been very low owing to the fire fighting.

"We soon learned that it was of no use calling a conference with the staff for the day following a raid. This had to be done immediately.

"Reported burst mains during blitzes

were usually all isolated by the time the 'all clear' signal sounded, and by that time all necessary calls for mutual assistance, plant, water trucks, etc., had already gone out. In special cases only has work been started during the dark on air raid damage in Bristol.

"*Day Following the Raid.* One of the first jobs is to organize great numbers of water trucks necessary for an emergency supply. These have probably been on the move since our message during the raid the night before, and the drivers are usually strangers to the city. The Boy Scouts' Association has lent most valuable aid by supplying scouts to meet the water trucks at their assembly or filling points and to direct them to predetermined areas and streets.

"In the meantime, gangs of laborers and pipe layers sent by neighboring authorities have to be organized into many repair gangs. Repairs to the big mains have been accelerated by the use of mobile cranes in place of shear legs. Difficulties regarding plant have imposed limitation; we often could have usefully employed more small compressors of a two-wheel type suitable for towing by cars. Some of these we have endeavored to obtain—or at least have filled up the necessary forms in that connection.

"We have been able to meet the feeding problems by enlisting the services of the W.V.S. and the Y.M.C.A. mobile canteens to deal with the repair gangs on outside work, by arranging to feed truck drivers at Y.M.C.A. feeding centers, and by feeding labor gangs, etc., at our own canteens.

"We have in stock quite a number of flexible jointed pipes for temporary connections, but have found steel tubes most useful for spanning craters and we rarely used any other form of temporary connection.

"*Emergency Supplies.* Many of our lorries and carts are fitted with trailing bars to take trailer pumps for providing emergency boosting in various districts of the city.

"*Chlorination.* Fractured mains are dosed with bleaching powder at 10 parts chlorine per million. If the mains are contaminated by sewage, etc., they are dealt with by portable chlorinator up to 50 parts chlorine per million. Occasionally the stirrup pump method has been used to introduce the solution through the hydrant.

"*Leakages.* During a blitz the inflow to the city is increased; after the blitz the consumption remains high while repairs are proceeding. Special watch is kept on waste, and our waste staff has been greatly enlarged since the war. On one occasion the services of a dowser were enlisted on blitzed areas. We have already cut off a great many services permanently.

"It is highly important to keep special records of damaged mains, services, meters, property, etc.; a special officer deals with this. All the big craters involving main breakages are marked on our mains plans.

"*Special Damage to the Bristol Water Works.* At one of our depots during a blitz, the staff sheltering in the basement had to evacuate quickly as a 24 in. main outside had been fractured and had started flooding the building. They had not long been upstairs when the building received a direct hit with a H.E. bomb. Apart from knocking them all down there were no casualties.

"On another occasion a H.E. bomb came down beside a reinforced concrete shelter at another depot, exposing the shelter on the side of the crater. Such was the curious effect of this bomb explosion that men in the shelter did not know a bomb had come down.

"Another time a bomb made a direct hit on one of our mains under the water."

Blackouts and the Electric Industry. ANON. Edison Elec. Bul. **10:** 1 (Jan. '42). *Excerpts.*

"The outstanding problem presented by blackouts is not a technical one, but an elementary problem in human relations, although not necessarily easy of solution just because it is elementary; it is merely that of abating confusion in a situation that inherently tends to create confusion. While this situation may not be particularly serious at this stage, it might well become awkward if general principles are not well established before the actual execution of blackouts is thrust upon the general public.

"Hysteria and misconceptions hold potentialities for doing far more damage to life and morale than any conceivable air raids over this country. Assistance in allaying unjustified fears in their localities will be at least as valuable a contribution of the utilities and their employees to civilian defense as their part in the execution of such blackouts and other defense measures as may be considered necessary by the proper authorities.

"The greatest difference in the conditions applying to Great Britain and the U. S. lies in the obvious dissimilarities in the geographical and military situations. When Great Britain undertook to blackout, it was well understood that hostile air raids would occur, probably with great frequency and regularity; therefore steps were taken to blackout the whole country for the duration of the war or until the military situation has changed sufficiently to preclude the probability of damaging air raids.

"In America, quite a different situation prevails. The air raid precautions that may be undertaken are for drill purposes, and to ascertain how it shall be done if it has to be done in a more permanent way. It should be everywhere emphasized that normal activities shall be interfered with as little as possible. There is no responsible opinion that hostile air raids will actually occur under the existing military situation.

"Local governments may practice blackouts within their jurisdictions and enforce their orders through their police power. Co-ordination between adjacent municipalities or within more extensive areas may be effected by area boards or councils for this purpose. In one state a statute relating to blackouts and air raid protection has been enacted.

"Where the Federal Government becomes concerned, the statutory powers for dealing with police matters resides in the War Department and this is habitually decentralized. At present, in coastal areas, orders pertaining to blackouts will come from the appropriate interceptor command of the Army having regional jurisdiction, and from there will be directed to local civil authorities who will have responsibility for executing blackouts.

"It is well to remember, also against the time of real exigency, where the basic statutory authority resides; namely, in the local police authority, in the state police authority and in the War Department's designated regional Commanding Officer.

"At the outset, early in December, there appeared the natural disposition on the part of civil authorities to want to extinguish the sources of electric power supply by pulling the switches in stations and substations. The military authorities, acquainted with British experience, saw the necessity for keeping the circuits energized. The reasons for keeping them energized may be summarized for use where required:

"The power system supplies energy for all manner of electric loads as well as lighting. These comprise motors and all motor-driven apparatus, such as elevators, ventilating fans, pumps; electrical heating devices of many kinds; refrigeration; practically all radio receiving sets; broadcasting, telephone, telegraph and signal services. They furnish the power to keep vital industries going, for essential lights in hospitals, at emergency exits of buildings, etc., and they supply a large amount of lighting that is important to the well-being of a community and can successfully and practically be screened.

"The responsibility for extinguishing lights is properly placed on each individual consumer and it should be contemplated that he will turn out all lighting at the final circuit switches, or even at individual fixtures in order to leave other services unimpaired; it is in general not desirable that individual consumers shall turn off the main switches to their installations. In the case of premises where no responsible person is present during the hours of darkness, some ordinances provide that all lights shall be extinguished when leaving the premises. Others require that signs and billboards not normally under immediate control shall be extinguished for the entire duration of the emergency unless such control is provided.

"Since signs and displays not under immediate control are normally controlled by time-clocks or photo-sensitive

relays, various expedients are being tried or considered, such as the employment of patrolmen, the use of control circuits, etc. The successful use of patrolmen appears to be of doubtful value on account of the probable infrequency and irregularity of alarms and the considerable uncertainty that they would be able to cover a reasonable beat in the required time following an alarm. Remote control systems have the disadvantage of requiring material, labor and time. The most promising development appears to be contained in a proposal that the owners or lessees of billboards or premises having after-sundown display shall provide switches accessible from the street whereupon it shall be the duty of air-wardens to turn off these switches in the event of an alarm; the effectiveness of this measure will, of course, depend upon the efficient organization of the air-warden system.

"Although not mentioned in some of the earlier and hastily executed ordinances, there appears to be a tendency to provide that emergency and exit lights normally required for multiple dwellings, places of public assembly, etc., shall remain lighted but suitably shrouded. Some of these lights have been required to be on separate circuits heretofore; in such cases their selective treatment will be relatively simple.

"Electric utilities will ordinarily have direct responsibility for whatever requirements may be made for dimming or extinguishing street and highway lighting. Initially the requirements may call for complete extinguishment within two or three minutes of a warning alarm. This requirement is fairly easy to meet in the case of series lighting circuits, both for the circuits controlled directly from attended substations and those remotely controlled through pole-mounted constant current transformers in cascade connection. The problem is not equally simple for circuits controlled by time-clocks or photo-sensitive relays, but this type of control may not be usual in large or thickly settled communities.

"Serious consideration is being given to the provision of very dim auxiliary street lighting systems patterned almost directly on British methods. *While substantially similar methods have apparently proved to be satisfactory in Great Britain, there is strong reason to doubt that they would be justified here.* [Italics author's.] Taking into account the very large amounts of already scarce materials which they would require, the large number of manhours of labor, the time that would be required to construct such systems, the substantial waste of electricity, the limited time that there is reason to assume they would be in actual use, the very small value of this dim light under our prevailing climatic conditions, and the good prospect that alternatives, if the value of the general scheme should become apparent, could be devised which would serve the purpose better at far less cost in scarce materials and labor, all serve to cast doubt on the value of the British scheme for use in America. In the event that some provision of auxiliary street lighting is required, it is strongly recommended that this should be done by stages, placing such lights first at only the most important street intersections, and then proceeding to the points of next importance, as experience clearly justifies this further expansion. To conserve materials, this should be done by improvisation, exercising ingenuity to make a maximum use of existing resources with a minimum requirement for new material and for labor.

"If a low level of illumination is demanded, there appear to be promising possibilities in the method of reducing the current in series circuits to the desired amount by reduction of the primary voltage supply to constant current transformers. The most conspicuous advantages of reducing the candlepower of street illumination in place are that it requires very little new material and that it uses existing locations presumably well chosen and familiar to the inhabitants.

"The city of Chicago is considering a scheme to effect the protective concealment of military objectives in the metropolitan area by altering the characteristic light patterns of that area as it appears from the sky. If such a scheme were to come into use, dimming of sections of existing street lights would undoubtedly be a factor.

"If illumination is to be provided, the lights must be shrouded in any case to prevent any upward emission whatever, and probably to provide a cut-off substantially below the horizontal plane. It is sufficient for specifications to establish the angle below horizontal at which cut-off is required and to require tightness against any upward leaks and adequate mechanical stability. It is the consensus of opinion of utility officials that have had any experience that complete extinction of street lights in a blackout is preferable to any scheme for dim lights.

"Most local ordinances contemplate immediate cessation of all vehicular traffic, except police, fire and emergency vehicles, following an alarm signal. In order to avoid confusion it will be desirable to arrange with the appropriate authorities in advance for emergency classification of appropriate vehicles, and for the required markings, special lights, etc.

"The experience of electric utilities on the West Coast, where air raid precautions have been more urgent than elsewhere, indicates that it is unwise for ordinances to deal in detail with provisions that may require specification. Experience already has indicated that prompt and perhaps drastic changes will be required in many details and if these details are frozen in laws or ordinances it is difficult to change them quickly to meet necessities.

"Some communities, faced with the police, traffic and other problems involved in air raid precautions, have made provision for the substantial increase of police force strength by means of special policemen for general purposes, and many communities are providing limited police powers to air raid wardens of various classes.

"In view of the public responsibilities of utilities, however, it may be necessary, according to established local requirements, to provide some kind of special police, or A.R.P. warden status or other unmistakable identification for repair crews and emergency workers. It is equally important to ascertain that such workers shall not have been drafted for general A.R.P. work at the expense of their availability for the emergencies for which they are particularly qualified."

Auxiliary Water Supplies for Fire-Fighting. ANON. Wtr. & Wtr. Eng. (Br.) **44:** 11 ('42). *Excerpts.*

"One lesson which the "blitz" fires of last winter brought home to local authorities was the vital importance of an adequate reserve water supply. . . . Many municipalities have already installed auxiliary systems consisting of overland pipes from convenient local sources to feed supply tanks at strategic points. . . . The pipes have hitherto mainly been of steel—but latterly high authorities have begun to look with favor upon an alternative material . . . asbestos-cement. This provides piping of great toughness which is nevertheless extremely light, and most easily transported and laid. It also has the valuable property of resisting corrosion and incrustation, and thus preserving perfectly smooth bore.

"Use has also been made of sea water. Asbestos-cement pipes have been laid from shore . . . ; through these, water is pumped into storage tanks; and from here it is conveyed in a double line of pipes to static water tanks in other parts of town. In all, many miles of 9-inch asbestos-cement piping are employed.

"This scheme, which was initiated at the suggestion of the local A.F.S., will, it is believed, have its counterpart in many other coastal towns, in addition to the schemes already being carried out in inland centers, where local supplies of water from lakes, rivers, canals, etc., are being harnessed to the service of national defense."

Water Supply and National Defense. (*Outline of Talk*) F. H. WARING. Ohio State Univ. Eng. Expt. Sta. News. **14:** 1: 10 (Feb. '42).

A. *Scope of This Discussion*

1. Limited to the problem of protecting the public water supply against sabotage (not to be compared with English experience by bombing, or with actual wartime operations near bases of operations)

2. Specially directed toward those municipalities, large or small, where defense industrial operations are located

3. No specific examples of Ohio water works need be mentioned, because pub-

licity might invite activity of radical elements, as distinguished from planned efforts of saboteurs

B. *Precautions Concerning Individuals*

1. Employees:
   a. Investigations of loyalty and dependability
   b. Provision of proper identification
      (1) Large buttons (2″) with photographs plainly visible
      (2) Cards with signatures of employees and employers
      (3) Authenticity of both by using department seals, etc.
2. Outsiders:
   a. Those having official business—proper identification, in company with proper official, letter or card furnished at outer office or gate, to be surrendered upon leaving
   b. Visitors—discourage (and try not to antagonize) individuals or groups from making inspection trips. Emphasis upon adults (exceptions possibly are elementary and high school students accompanied by teacher)

C. *Protection of Physical Property*

1. Enclosures:
   a. Fencing by cyclone fence, preferably double line, 100′ apart, perhaps barbed wire on top, and
   b. Electric current charged for operating alarm signals
   c. Suitable gates kept locked, or watchman on duty—applicable to large areas
2. Guards:
   a. Watchmen should be armed (rifles or sidearms, preferably former in large plants)
   b. Only trusted personnel (e.g., present spare employees or former employees)
   c. Uniformed, if possible (simple but distinctive), to establish easy identification to the public
   d. On duty 24 hr., shelter houses provided, placed properly, equipped with proper communications facilities with each other and with office
3. Floodlighting:
   a. Arrangements might be taken up with experts to get best results under poorest natural visibility conditions
   b. Locations best to frustrate attempts of saboteurs
   c. Vulnerable spots to be illuminated without calling undue attention to locations (Keep this information secret, within close circle of official family—not even guards to know all)
4. Communications and Alarms:
   a. Telephone inter-connections
   b. Alarm signals, in case of suspicious circumstances
   c. Time clocks for recording regular guard duty
5. Vulnerable Spots:
   a. Duplicate facilities, where possible, to avoid interruptions in service
   b. Remember damage to large structures requires time, skill, exact knowledge (Don't get panicky)

D. *Power Sources*

1. If steam pumping employed, provide auxiliary pumping units powered by electric or diesel equipment.

2. If electric pumping regularly used, provide auxiliary electric power from standby generator, diesel-operated.

3. If electric valve operation, provide auxiliary electric power unit to regular electric source.

4. For defense floodlighting, provide auxiliary electric power unit, diesel or steam, as the case may be.

E. *Supply of Materials*

1. General defense program of industry will have effect of making it difficult to obtain regular materials quickly. Reasonable supply of extra valves, fittings, piping, etc., warranted to anticipate needs.

2. A.W.W.A. staff has contact with priorities board to assist in obtaining water works materials.

F. *General Advice*

1. Provide inter-connections with adjacent municipalities for emergency service, especially where defense industries are located in one or the other.

2. Don't give undue advertisement to

presence of guards, systems of protection, etc., even if incidents occur.

3. If choices of procedures are offered, why not ask FBI to make suggestions re protection of water works against saboteurs?

4. Remember that neighboring cities can render valuable service in case of disaster, whether natural or sabotage.

Science and Defense. VANNEVAR BUSH. Science. **94:** 571 (Dec. 19, '41). In June '40 Council of Natl. Defense ordered formation of Natl. Defense Research Com. (N.D.R.C.), an emergency organization, to supplement Army-Navy development of devices and instruments of war, and to function in an executive capac. Advisory function cared for by National Acad. of Sciences. Consists of 6 civilians, 1 Army, 1 Navy officer. Composed of 4 divs. of 60 secs. manned by voluntary part-time and full-time workers, plus few technical aides paid by Govt. Operates primarily by contracts with universities, colleges, research institutes and indus. labs., initiated and supervised by 450 secs. in operation with about 120 contractors. Contracts drawn with intent that contractor (univ. or indus. lab.) shall neither gain nor lose financially through participation in such defense activity. About 500 in N.D.R.C. serve as sec. members, consultants, etc.; about 2,000 scientific men engaged in defense research through contracts; probably 2,000 helpers. Spent nearly $10,000,000 first yr. Approx. same amt. appropriated for second. Only shortage of personnel, rather than no. of problems or lack of funds would cause bottleneck. In almost every field, supplementing previous work rather than starting new. Very close liaison exists between Army-Navy officers and those of each N.D.R.C. sec. Relations cordial, and heartening mutual respect developed. Interchange of sci. and tech. information with Britain effected on excellent basis. In June '41, Office of Scientific Research and Development (O.S.R.D.) established to co-ordinate all defense research wherever it might occur. Two major divs. are N.D.R.C., described above, and Com. on Med. Research. Latter constituted much like N.D.R.C. and shares with latter in funds supplied O.S.R.D. to conduct med. defense research. Works primarily with Div. of Med. Sciences of Natl. Res. Council composed of 50 coms. Com. on Med. Research has close relation with U.S. Pub. Health Service and Surgeon Generals of Army-Navy. O.S.R.D. charged with duty of: (1) mobilizing country's scientific effort by providing focus at which all defense research considered; (2) supplementing work of Army-Navy, directly through own organizations, on instrumentalities and materials of war, and by med. research; (3) advising President as to status in this country of sci. research and development in relation to defense; (4) in co-operation with Army-Navy, initiating broad programs of research where needed; (5) carrying on research requested by countries whose defense considered by President as essential to defense of U.S. For example, Britain forced to drop much important med. res. due to immediately urgent matters. O.S.R.D. being aided by Natl. Roster of Scientific and Specialized Personnel, and Natl. Research Council, in locating competent personnel; also by Natl. Inventors Council, under Dept. of Commerce, to evaluate large no. suggestions from public. Story of work will be striking when revealed. Hint contained, however, in Battle of Britain, Aug.–Sept. '40. Invasion failed because: (1) British fighting forces in air more courageous, skilled, well and better equipped than invaders; (2) radio detection developed by devoted British scientists from '35 on, without much encouragement at times, offset element of surprise. This one development may have saved isle of Britain. O.S.R.D. matters handled secretly. A man permitted to learn confidential things only to extent necessary to function effectively. In working with outsiders, O.S.R.D. members listen but do not talk. Appointments to posts in organization made only after Army-Navy have carefully checked on appointee's complete loyalty. Scientists of country united and obtaining results.—*Ralph E. Noble.*

The Advisory Board on Sanitary and Public Health Engineering. ANON. Science. **94:** 602 (Dec. 26, '41). Members of Natl. Technological Civil Protection Com. appointed by Secy. of War, Jan. '41, agreed to act also as Advisory Bd. on San. and Pub. Health Eng. to Med. Div. of Office of Civilian Defense. Personnel listed. O.C.D. will have contact member on this com. as does War Dept. Regional san. engrs. appointed by O.C.D. Med. Div. to work through state defense councils with state health depts. in planning defense against belligerent action. Most important immediate duties to promote development of protective measures for public water supplies possibly subject to destructive enemy action. Will also consult with health authorities on emergency maint. of sewerage, san. facilities, garbage disposal, protection of food and milk supplies in disaster. Two regional engrs. already on duty.—*Ralph E. Noble.*

Selecting Army Camp Sites. ANON. Western Constr. News. **16:** 365 (Dec. '41). Many '17 cantonment sites found deficient in requirements for modern training of troops. Where practical these sites rehabilitated, but plans made for other new military establishments. General area in which army camp located detd. primarily upon need for military forces in that area and upon adaptability of area to training needs. Choice made by board of high ranking officials of War Dept. Sites may be up to 100,000 acres in extent, in general are 40,000–50,000 acres with 1 dimension approx. 10 mi. in length for triangular div. camps and 75,000 acres of maneuverable terrain for armored div. camp. Exact layout plan made by cons. architect-engr. under constructing quartermaster. Housing facilities to be provided for not less than 30,000 men, part of area should be comparatively level for barracks, review area, drill fields, ranges, etc. Many requirements for training areas affect site selection, arterial highways and railroads obviously vital matters. Three other important factors posed by camp selectors: (1) can adequate water supply be obtained or developed at reasonable expense? (2) will camp be free of floods? (3) will camp always be free of mud even in prolonged rainy period? If answer to any negative, site must be abandoned. Although architect-engr. has considerable latitude in adapting standardized plans to terrain, must adhere to certain principles as to location of hospitals with location to prevailing winds, etc. When members of Board of Officers look over proposed site, they must endeavor to visualize city of approx. 2,000 bldgs. that may be called upon to accommodate as many as 50,000 persons for as long as 5 yr.—*Martin E. Flentje.*

Army Camps Bring Municipal Problems as Well as Prosperity. ANON. Minnesota Munic. **26:** 155 (Apr. '41). Army camps and defense industries bring "boom town" prosperity, but Alexandria, La., finds that 125,000 soldiers in its environs bring problems in munic. services and facilities for city officials to solve. Normal pop. increased by thousands of constr. workers. Police increased due to trouble by camp-followers, not soldiers. For fire protection, city placed water pumper truck at disposal of military at one camp. From Nov. '39 to Jan. '41 bldg. permits inincreased from $31,000 to $216,000 monthly. Taxes not increased. City-owned utilities have apparently borne cost. New water connections made daily and previous consumers taking greater quantities. Increased demand for service has called for increased plant facilities with corresponding outlay.—*Samuel A. Evans.*

50,000 Troops as Neighbors. ANON. Munic. Finance. **14:** 22 (Aug. '41). San Luis Obispo County midway between Los Angeles and San Francisco, 3 incorporated cities: San Luis Obispo, 1940 census, pop. 8,881; Paso Robles, 3,045; Arroyo Grande, 1,090. Two camps constructed, Camp San Luis Obispo, 20,000 troops, 4 mi. east of San Luis Obispo and Camp Roberts, 30,000 troops, 11 mi. north of Paso Robles. First Local Defense Council in Calif. organ-

ized in San Luis Obispo. Constr. and maint. of roads to camp boundaries primarily county problem. San Luis Obispo changed into boom town by advent of 5,800 constr. men and families. New demands have taxed resources of city-owned water dept. Sewerage system overtaxed, disposal plant little more than preliminary screening process. Policing problems less with the soldiers than constr. forces. Possibility of 10,000 soldiers on leave on Sat. and Sun., making adequate recreation facilities necessary. Private capital encouraged to install recreation facilities. At instigation of defense council, county and city authorities agreed to suppression of organized vice, red-light district had been abolished, clandestine operation expected. Water works and sewerage system taxed by military at leave periods. U.S. Public Health Service has indicated dissatisfaction of present water purif. system and city hopes to remedy this situation with Federal aid. Bulk chlorination utlized at reservoirs, hard water but no *Esch. coli*, Army and Federal officials agree water is safe. In past 2 yr., 150,000′ of new water mains placed, all 2″ removed, present min. 4″. Present sewerage system inadequate, city does not have money for modern treatment plant. City council does not deem it sound financial policy to assume debt for facilities which would be used only for emergency. City officials recognize that city has a definite responsibility towards natl. defense, and appropriations being made from current revenue for needed public works, fire and police protection and using of reserves for water system extensions. Not deemed advisable to issue 30- or 40-yr. bonds for public works projects for emergency use.—*Samuel A. Evans.*

Defense Activities in Norfolk. A. PRESTON BREEDON. Munic. Finance. **14:** 13 (Aug. '41). Extension of defense activities, involving over a billion dollars, creates problem not so difficult of solution during progress of activities as afterwards. Much of work, shipbldg., requiring several years to complete. Norfolk Navy pop. estd. at 65,000. One of main problems water supply. Two army concentrations located on two sides of beach resort back about 5 mi. from 16″ water main supplying resort. In 60 days city installed 52,620′ of 8″, 10″, and 12″ cement-lined cast-iron pipe with valves and fittings. Some unused fresh water lakes connected to water system. Laying of larger mains involved about $500,000, 75% paid by W.P.A. Consumption of water for first quarter '41 exceeded corresponding period of '40 by 40%; ordinary conditions, increase about 1% per yr. Resulting increase in revenue expected to exceed addnl. operating cost. Believed Govt. will maintain activities on large scale after emergency. Realized that there will be business slump after emergency. Expected, however, that additional emergency expenditures will be more than offset by increased collections. Capital expenditures so far authorized by reason of emergency, primarily improvements for water supply, drainage and sewerage, part would have been necessary normally. Expected growth of city will continue in next 10 yr. as in past decade when population increased 11.3%.—*Samuel A. Evans.*

Bottling Plants Offer Emergency Drinking Water Source. ANON. Am. Chem. Soc.—News Ed. **20:** 185 (Feb. 10, '42). As emergency sources of drinking water if local water supplies are damaged by enemy action, use of facilities of more than 6,000 beverage plants in 2,900 cities and towns offered to Nation by American Bottlers of Carbonated Beverages, national trade assn. of bottled soft drink industry. Statement filed by organization with O.C.D. suggested possibility of chlorination of water in beverage plants. Bottle-washing and sterilizing equipment of plants would provide safe containers for water and for distr. in large areas. O.C.D. has suggested, as preliminary step, that proprietor of every bottling plant give to defense director or co-ordinator for his community written information concerning availability of special water-treatment equip. in plant and independent sources of water available in emergency.—*Selma Gottlieb.*

ADMINISTRATION, PERSONNEL AND PUBLIC RELATIONS

Types and Operations of Defense Contracts. MARK S. MASSEL. J. Accountancy. **73:** 45 (Jan. '42). Contract of any specific company should be investigated before any definite acctg. or business approach developed, no easy detn. of which is best type of contract, for either govt. or industry. Most popular type fixed-price agreement based upon low bids. Negotiated contracts fewer, may contain fixed prices, fixed prices subject to escalator provisions or cost-plus provisions. So-called letter-of-intent contract developed in '40, govt. notifies contractor formal contract will be entered into and directs him to start production. War-time contracts designed for use in war, some forms permit govt. and contractor to enter into agreements with min. of preliminaries, others really would be compulsory requisitions for contractor to mfr. for govt. Under two acts passed in '40, War and Navy Depts. may make advance payments, up to 30% of contract price. Complete description of contractual situations not feasible—no substitute for scrutiny of individual contract to ascertain what combination of its separate provisions may mean. As for application to individual business problems, govt. contracts no more intricate than many other business practices. Individual judgment still retains paramount importance.—*Samuel A. Evans.*

Some New Problems in Industrial Sales. J. F. GASKILL. Edison Elec. Inst. Bul. **9:** 485 ('41). War here and that fact calls for extreme effort from industrial sales groups to speed production. When war over many difficult problems will arise; if while doing our utmost to answer demands of war economy, viewpoint is kept on transit from war to peace, contribution will be of real value. Many present questions of future import; handling of industrial expansion, advisability of promotion, development of new applications, direction of applications necessary to normal operation of customers' businesses so that loads will continue with business, elimination of needless red tape, adjustments in organization and training of personnel so that highest eff. will prevail, market studies so that productive spots will be known when promotion intensified, situation with respect to competition when war is over. All business due to defense program not permanent, each case must be settled on its own merits, usual methods of promotion not applicable. Resumption of promotion should be at about transition period from a seller's to buyer's market. Any application which lends itself to selling in hard times should be developed. When conditions indicate need, most productive selling will probably be that which represents greatest operating economy to customer and lowest owning cost to him per dollar of revenue to us. When purchasing power shrinks and business falls off, selling will become more or less difficult, criterion being relations with customers. Methods that have been used in meeting of market problems over period of time will undoubtedly have more weight than proclaiming our virtues in times of adversity. Any organization refinement and personnel training which can be made now and brought to smooth operation are present problems which, if solved, will ease future stress. Last depression demonstrated that market primarily interested in those things which promise economy in investment and production cost, or things which make business or product more attractive to market. Some time after war, competition should become stiffer than ever. Different mechanized effort will have been developed, numerous second-hand machines will be available. Undoubtedly, only thing to be done at present is build up market relations and keep in mind effect of possible rate changes. Some anticipated situations may not develop in post-war period because of impact of conditions now unknown. Should this occur, preparations

would not have been in vain, as they would be reflected in improved operations, in happier market.—*Samuel A. Evans.*

A Survey Report. Pub. Mngmt. **23:** 259, 298 (Sept., Oct. '41). *I. Safeguarding Managerial Time.* No accepted set of duties and responsibilities for city mgr., nor any "guaranteed" techniques for solving admin. problems. Management has, however, certain common characteristics wherever found. Functions which city mgr. cannot delegate without surrendering title of chief administrator are: organizing, planning, directing, co-ordinating, controlling, representing admin. in contacts with council, finance and personnel management (this would apply equally well to any mgr.). Most city mgrs. prefer "open door" policy, not meaning they will see any visitor at any time and for any purpose, but those whose business cannot be transacted with anyone else, or who insist on seeing him. Interviews with dept. heads essential; but heads must be delegated as much authority and responsibility as possible. By inspection and reports, mgr. can be kept in close contact with work being done. City mgr. must have advice of dept. heads in solving numerous problems, and know what questions to ask them, especially when execution of certain procedure affects two or more depts., time often being saved by such advance conferences. Conference must be carried through with intention of accomplishment of objective, memorandums later being distributed to conferees of definite conclusions reached. Mgr.'s direct supervisory contacts with subordinates should be reduced to min. consistent with adequate control. Auxiliary services provide convenient channels through which mgr. can apply controls, these services not managerial, i.e., acctg. devices are used to enforce budget, but acctg. work not under close personal supervision of mgr. If no. of dept. heads too large, mgr. may appoint dependable admin. assts. They act only by and through authority of mgr., who, by assigning them tasks, does not relinquish control or responsibility. Successful management depends, in large part, upon quality and amt. of constructive thinking by mgr. Routine work is greatest obstacle standing in way of mgr. who needs and wants to give more attention to larger admin. problems. Constructive thinking most likely to occur when mgr. has mastered art of unhurried management. Any mgr. may find it advisable to keep time record for week and then analyze it. City or anyone cannot afford mgr. unless he is allowed time to think. *II. The Selection of Department Heads.* Staff of capable dept. heads essential to successful management; one incompetent head can disrupt entire organization. Selection of subordinate executives one of most important tasks of mgr. Test of his executive ability. His own position may depend upon his skill in selecting right man for right place. Question arises of filling position by promotion within organization or whether residence requirements will be waived. Mgrs. who have provided for understudies or assts. have had little difficulty in filling vacancies. At times, not possible to go outside for subordinate heads, or various professional groups may be called upon for advice, e.g., eng. groups, medical societies. Experience has shown that in going outside there will not be an avalanche of qualified applicants. Job specifications should consist of enumeration of duties of position and min. qualifications. Mgrs. agree that dept. head should have organizing and planning ability, knowledge of job or of field of activity he is to head, ability to secure co-operation of subordinates, energy and drive to do job, and loyalty. Specifications should fit position and not man holding it. Should be clear that knowledge of "local situation" usually not as important as a knowledge of field. Within few months after appointment, outside appointee usually will have a greater combined knowledge of deptl. operations and "local situation" than will local resident who lacks broader experience. Specifications prepared by natl. professional organizations, with probably minor revisions, can be adapted for local use. Mgr. can make active search on competitive basis among

qualified individuals. This may be done by publication in journal of appropriate professional organization, contact with other mgrs., advertising. Uniform application form advisable, comparisons then may be made as to, personal information, education, academic or professional honors, publications, memberships, chronological employment record. Written examns. may be used for positions involving technical knowledge and experience, as in case of water works engrs., sewage treatment plant supts. and other technical positions. Unassembled examns. permit objective selection based on education, training and experience by a systematic comparison. Objective selection not possible by interview alone. By it mgr. may ascertain many factors of personal suitability, but not technical or administrative ability, initiative, sincerity, perseverance and intelligence. Responsibility for final selection of dept. head belongs to mgr. He has definite obligation not only to city or organization, but to subordinate employees in dept., and appointee, to see that latter properly qualified.—*Samuel A. Evans.*

Work Measurement in the City of Los Angles Building and Safety Department. IRVING TENNER. Munic. Finance Officers Assn. Cost. Acctg. Bul. 1. (Dec. '41). Measurement of work loads as aid to admin. and eff. Dept. governed by 5 comrs. appointed by Mayor for 5 yr., employees civil service. Divs. of Dept. are: Bldg., Elec., Plumbing, Heating and Ventilating, Fire Alarm and Police Signal, Admin., Acctg. Permit required for constr., demolition or repairing of bldg. Bureau of Budget and Efficiency makes recommendations on dept.'s budget. This necessitated trips with field inspectors, study of past statistics, interviews with outside constr. men and engrs. Each permit requires about 12 inspections and each office engr. checks 3.8 plans per day. Avg. no. of field inspections and mileage per inspector day detd. Monthly report made by Dept. to Bureau of Budget and Efficiency, showing permits issued, no. of inspectors and inspections, mileage, etc. From this data units of amt. of work accomplished computed; thus in future from no. of permits, requirements can be readily detd. For example, on basis of past records plus forecasts of building trends, no. of permits can be forecast and no. of inspectors, other items and future budget can be detd. Deviation from stds. also obvious. Found that when activities examd. on group basis, inequalities tend to cancel out. More true if investigation period is a year or more. Report contains 9 figs. illustrating method of collecting data and its anal. Important points to remember in analg. data and setting up stds.: investigators must be familiar with work, make actual physical investigation of activity, opinion of outside experts, anal. of past performance, 2 or more independent methods for checking, large group and long period, careful investigation of variations from std., change stds. as required, figs. not exact, results depend on ability of investigator to exercise proper judgment.—*Samuel A. Evans.*

Water Works Administration Bodies. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **4:** C: 8: 21 (Dec. '41). Tabulation given of member municipalities, showing public bodies which operate and administer water works systems, pop. and charge for fire protection outside munic. boundaries, if any. Of 122 communities listed, water systems of 42 are administered by the council or committee of council, 78 by commissions, boards or committees, and 2 privately. —*R. E. Thompson.*

Administration of Water Works Systems in Canada. ANON. Can. Engr.—Wtr. & Sew. **79:** 6: 108 (June '41). Only few systems privately owned. Of 109 municipalities answering recent inquiry, 70 reported water works to be controlled by public utilities commissions with elected comrs. In 28, system under control of munic. council. In Ont., of total of 91 systems, 69 controlled by utility commissions and 22 by councils. In many cases, same commission controls elec. system. Fire protection charges usually included in munic. taxes. All surplus funds must be paid

to munic. council and if not needed for debt charges can be used for tax reduction. Practice seldom popular with commissions, who feel that surplus should benefit water consumers rather than taxpayers.—*R. E. Thompson.*

Importance of Annual Municipal Reports. ANON. Can Engr.—Wtr. & Sew. **79:** 12: 18 (Dec. '41). Brief discussion of value of annual repts. to other officials engaged on similar problems. To be of most value, such repts. should be widely distributed and so prepd. that desired information may be obtained therefrom with min. of effort. Author of rept. should assume that reader will not be familiar with local conditions and include description of plant for which statistics given. Figures for costs, etc., should, of course, be reduced to units by which results obtained can be compared with those obtained elsewhere. Munic. repts. could be made more useful if anals. prepd. by some central office. This now done by govt. depts. and by some technical assns. Data collected and distributed by Can. Sec.—A.W.W.A., indicates what may be accomplished in this direction. Examples of instructive comparative figures taken from '40 reports of Ont. water and sewage works presented. Extensive compilations of similar data would be most helpful to munic. officials. If every municipality would make prepn. and publication of such repts. obligatory, benefits would far more than compensate for trouble and expense involved.—*R. E. Thompson.*

Relative Value of Utility Systems. C. F. LAMBERT. Eng. News-Rec. **126:** 654 (Apr. 24, '41). Record of values of 5 utilities—water works, electric light plants, street railways, and natural and artificial gas systems—originally published in '25 and brought up to date annually in '31-'37, now brought up to Jan. 1, '41. In computing trends, about twice as many plants now used as originally. Data re: water works based on 68 items in 25 systems, including land, pipe, pumps, motors, filters, hydrants, etc. Annual values on '13 and '26 bases and monthly values during '40 on '13 base given in tables and annual avg. values, and preceding 5- and 10-yr. avgs. on '13 base depicted graphically. In '40, annual avg. for water works was 195.2, taking '13 value as 100, and 103.5, taking '26 costs as 100. Monthly avg., on '13 base, varied from 191.1 in Jan. to 196.8 in Nov. and Dec.—*R. E. Thompson.*

Old-Age Security and the Treasury. GEORGE BUCHAN ROBINSON. J. Accountancy. **73:** 7 (Jan. '42). Treasury's proposal to increase old-age tax rates unfavorably received by press. In '35, Treasury urged higher old-age taxes, in '39 suggested reduction, another reversal now appears to require explaining. Est. of '35, 5.06% of payrolls, '38 est., 7.88%. To restore 1980 reserve-fund expectation, 3 alternatives, increase old-age tax rates 50%, enact immediate general tax subsidy, abandon purpose of accumulating reserve fund. Treasury accused of having reserve plan not for social security but to retire govt. debt. Social Security Act appears to be at crossroads. Bonuses so great that anything less than general distr. of them untenable. Such general distr., however, unaccompanied by present payment of the costs thereof, with the disbursements, instead, merely "financed" by using contributions and employers' taxes of 2% of payrolls, while liabilities for pensions of probably four times 2% accrue unnoticed; only one outcome, creation of annual debt for pensions of, say $7,000,000,000 with no advance preparation of consequence. Greatly to advantage of our present near-old, surely, but cost would remain to be paid. Recommended Treasury publish annually ests. of cost of program. Suggested that general-tax subsidy be faced at once. Advisory Council justifies by stating, public, as distinguished from insured group, would benefit from program and should pay ½ of cost. Any equitable method of covering self-employed group, farmers, should now be promulgated. Amt. of govtl. waste involved in presuming all insured persons to be needy at age of 65, should be studied. On what grounds, discovered since '35, does Treasury presently believe that old-age taxation has primary refer-

ence to monetary control? Old-age cause should not be wrecked on shoals of financial decisions reached, as in '39, without due attention to accruing liability for pensions, magnitude and meaning of bonuses, significance of discovery that costs were underestd. in '35, and intimate relation of form of old-age program to Treasury's fiscal condition and prospectus.—*Samuel A. Evans.*

Water. ROBERTA WHITEHEAD. J. N. E.W.W.A. **55:** 384 (Sept. '41) Reproduction in solid, rather large type (18 pt. bold face) of children's story *Water* used as reading material in Second Grade of Shady Hill School, Cambridge, Mass. Story summarizes variety of class room discussions and expts., including action of ferric alum floc on turbid and colored waters, bldg. of model-table watershed and reservoir, standpipe, distr. system and simple sand filters. Author states material and subject easily understood by 7-yr. old children. Quotations:

"A reservoir looks just like a pond or lake
but there is something special
about it.
No one ever swims in a reservoir
or fishes in it
or rows a boat on it. . . .
Because the water in a reservoir
is water that people will drink
and so it must be kept clean. . . .
It never runs up
and it seldom stands still. . . .
You cannot tell
just by looking at water
whether it is clean enough to drink.
You cannot tell by tasting water
whether it is safe to drink.
There might be germs in it.
You cannot see the germs
unless you look through a microscope,
and you cannot taste them. . . .
Down from the standpipe
and up in the houses.
All the clean water you want
whenever you want to use it."

[Thought indicated (and so well illustrated) by author, that story of water supply and treatment is instructive and interesting even to children, confirmed in many questions asked by 8-yr. old girl, whose interest in water works stems from her acquaintance with man described as:

"He makes different kinds of tests
and then he knows
whether it is really clean."

Copies of article would be valuable addition to any water works library.]—*Martin E. Flentje.*

ACCOUNTING AND FINANCING

The Depreciation Problem During the War Crisis. FRANK B. WARREN. Pub. Util. Fort. **29:** 149 (Jan. 29, '42). During existing emergency, extensive addns. made to public utility plants, for relatively short-lived communities, due to defense activities. Appropriate rates for depn. on short-lived plants concern of Federal and state regulatory bodies. Service-life ests. still informed guesses, fair dealing with consumers involves, always, that resulting depn. rates be consistently related to rate base. Public utility counsel generally succeeded in divorcing subject of existing depn. for valuation from depn. as annual cost or operating expense. Problem of reconciling relatively large depn. reserve with relatively small deduction for accrued depn. in detg. value, then reconciling deduction made for valuation purposes with relatively high annual expense rate, has engaged attention of regulatory commissions and courts for many years. Assumed that property represented by difference between reserve on books and existing observed depn. not capital upon which the company entitled to earn fair return, since it represents involuntary contribution of capital by consumers and not payment for service. Illinois court, however, voided this assumption. Court usually avoids vague allusions to "loss in service value," "contribution to fund for replacement of property worn out in service." Expense rule, by itself, appears to permit detn. of annual expense on basis of estd. service lives using straight-line acctg. methods. In contested rate proceedings, courts have

usually made one ultimate finding, order of commission will or will not result in confiscation of company's property or order is void for lack of procedural due process. Courts have made statements which regulatory commissions, for guidance, have accepted as rules of law. Capital consumed in service no longer exists for rate-making purposes. Capital losses due to functional depn. not observable, but occur uniformly over service life of property. No difference in incidence or effect of obsolescence or inadequacy for valuation and expense purposes. There exists an equitable estoppel against utility making inconsistent claims of capital loss or value dimunition in same proceeding. If utilities are estopped from introducing deferred maint. as existing depn. no confusion will exist in record of proceeding. Millions of consumers' money wasted by fallacious theory that accrued depn. can be detd. by "looking at" something, instead of using reliable experience data and expert knowledge.—*Samuel A. Evans.*

Cost Accounting for the Water Department. M. CLYDE FOX. Southwest W. W. Jour. **22:** 12: 15 ('41). No true cost acctg. can be had without correct general acctg. and cost acctg. as applied to units may be accurately developed wherever gen. acctg. system properly installed and maintd. Eng. and acctg. depts. should cooperate wholeheartedly to use any system successfully and to be able to develop statements and reports which can be understood by the ordinary business man after he has become interested enough to study them. *Manual of Water Works Accounting* highly endorsed.—*O. M. Smith.*

Expenditure Accounting for Smaller Counties and Cities. JOEL HUNTER. J. Accountancy. **72:** 17 (July '41). Most frequent criticism of govt. at present relates to character and extent of expenditures. Govtl. acctg. not simple, yet a primary step in expenditure control. American theory of public finance requires estg. of expenditures in advance, and budget is required for legislative authorities. Adequate system of govtl. expenditure acctg. must provide for commitment, accrual, and disbursement. Commitments authorized and made against appropriations charged against each acct. Vendor's bill charged against appropriation acct. and encumberance for corresponding commitment removed. In govtl. acctg. three sets of entries for each expenditure, private business normally two for accrual basis, one for cash basis. Chances of adopting in smaller communities appears remote. If applied to smaller community all expenditures must clear through single officer. Requisitions filed with a bookkeeper, who ascertains if funds available, bookkeeper files purchase order in file folder, having one for each expenditure acct. in budget. Vendor's bill recorded and charged against proper appropriation acct. Trial balance should be made at appropriate intervals. Emergencies taken care of by emergency purchase order blanks with governing rules and holding officer strictly accountable. A no. of expenditure accts., including regular payroll, encumbered by one blanket commitment for entire fiscal period. Page chart shown representing adaptation of proposed method of typical acct. from appropriation-expenditure letter. Plan would be subject to abuse in absence of co-operation in sending purchases through central agency.—*Samuel A. Evans.*

Governmental Cost Accounting in the Los Angeles Area. IRVING TENNER. Munic. Finance Officers Assn. Cost Acctg. Bul. No. 2 (Dec. '41). Following city depts. considered: Playground & Recreation, Health, Public Works, Bldg. & Safety, Water & Power, Harbor. Each dept. headed by board of 5 comrs. appointed by mayor, approved by council, 5-yr. term. Excepting Public Works, each dept. supervised by mgr. appointed by board. Acctg. decentralized, chief accountant each dept. responsible to board. City Controller, designated by charter as auditor and general accountant, has supervision of handling all city money, exercises control over and keeps records of funds and appropriations, acctg. methods prescribed by him, changes in system must be approved by city council. Health dept. has chief ac-

countant and for acctg. purposes is broken down into 18 divs. Gen. admin. overhead proportioned among divs. in ratio of its total to total current expenses allocated among divs. after overhead has been allocated to it. Public Works dept. organized into many bureaus, acctg. performed by Bureau of Acctg. In maint. work and refuse collection, costs on unit basis. In Dept. of Water & Power, cost acctg. work directed primarily to securing costs of constr. Est. of probable cost and authorization precedes work. Upon approval of proposed project, record kept of constr. costs, including direct expenses and overhead. Projects closed out monthly. In Los Angeles Co., with exception of budgetary acctg., system decentralized. Co. auditor keeps record of appropriations and appropriation expenditures of each dept. Some depts. have procedures for obtaining information not required for appropriation acctg. purposes, as cost acctg. procedures. Co. auditor installed most systems, although a few depts. have established their own. —*Samuel A. Evans.*

Obsolescence of Water Plant Equipment. EDWARD S. HOPKINS. 15th Ann. Conf. Md.-Del. Wtr. & Sew. Assn. ('41). p. 30. Heavy machinery like conveyors, elevators, cranes, etc., usually amortized on 5% basis, i.e., cost spread over 20 yr. For other devices like feeders, chlorinators, loss of head or rate of flow gages, usually 10 yr. For control apparatus, usually 5 yr. When no longer possible to get replacement parts for old machinery, latter should be scrapped and new purchased. Replacement of equip. upon basis of eff. desirable. Careful survey of operating costs over last 5-yr. period, however, should be made. Cost acctg. on certain equip. sometimes desirable. Repair with home-made parts only in emergency as practice leads to reliance on one individual rather than on std. auxiliary parts. All types of machinery should be tested frequently.—*Ralph E. Noble.*

Financial Policies for City-Owned Water Systems. ASHLEY G. CLASSEN. Southwest W. W. Jour. **23:** 3: 29 ('41). Publicly owned utilities, as a rule, meet and discharge expense of operation and maint. and interest and sinking fund requirements on bonded debt, but rarely do they maintain ample depn. reserve or provide reasonable excess of income over and above expenditures for purpose of financing normal growth, expansion and improvements. Such policies wrong because: consumer is paying more than he should; they defeat major premise of public ownership—that of providing product or service at as low a price as by private enterprise; ready availability permits indulgence and extravagance by public officials; and eliminates possibility of pay-as-you-go policy. Politics prevent bldg. of reserves and execution of proper and correct financial policies. Statute could be enacted enforcing correct and long-range financial policy if demanded by public.—*O. M. Smith.*

Who Owns the Utilities? ALBERT W. ATWOOD. Pub. Util. Fort. **27:** 588 (May 8, '41). In very real sense, the people own the utilities, author declares. Before depression, large corporations, especially utilities, boasted of no. of small stockholders. Campaigns were put on to sell stock to employees and customers. Theory of "customer ownership" has its flaws, customers and consumers have not the same objects. Bank failures of '32-'33, drop in real estate, business failures and foreclosures tended to eliminate "customer ownership"; corporations do not boast of extended stockholders when dividends are nil. New Deal's drastic legislation and govt. utility competition did not help. Emphasis shifted from individual savings and old-fashioned thrift to social security. Pendulum swings, utilities and other basic industries weathered depression and effects of adverse legislation, dividends were passed, stocks dropped; then revival and restoration followed. Long-range trend of industry and utilities to spread out over wider areas of ownership regardless of booms and depressions does not mean there is a steady increase every year in stockholders of every corporation. Significant that ever-increasing no. of institutions, representing security, public welfare and enlightment are becoming utility stockholders. Might be un-

wholesome condition for the utilities in South and West if big life insurance companies in Northeast control them. Many states, however, prohibit by law their buying common stock, and there has been no public evidence of four largest insurance companies trying to exercise control. Many salaried men now invest indirectly by buying life insurance and retirement income, which forces insurance companies to buy bonds and preferred stocks. In some of largest utilities, no. of women stockholders greater than men; accts. on stockholder's lists in women's names do not turn over as fast as men's. Importance of small stockholder constitutes one of moot questions of corporate policy and modern finance. He may hold stock in many corporations. One of largest utilities modest boast is that ownership is very fair and accurate cross-section of distr. of wealth in this country. Ownership of "private utilities" from this viewpoint, is special form of public ownership operated under public regulation without political management. Shift in ownership from voluntary investment to political control, involves change from ownership by public, organized in one way, to same ownership organized differently. Any financial benefits to tax-paying and rate-paying public, would be subtracted from institutional supporting group. On the whole, shift would pretty nearly even up. Probable effects of alteration in utility status should be recognized and considered. Unfortunately, situation has received little attention in voluminous literature and debates on utility regulation and ownership.—*Samuel A. Evans.*

HEALTH AND HYGIENE

Typhoid in the Large Cities of the United States in 1940. ANON. J. Am. Med. Assn. **118**: 222 ('42). *Excerpts.* (Reprinted by permission.) Previous annual summaries have been reproduced in the Journal as follows: **20**: 257; **21**: 963; **22**: 1122; **23**: 1059; **24**: 1066; **25**: 1157; **26**: 939; **27**: 1593; **28**: 1123; **29**: 1177; **30**: 1456; **31**: 1561; and **32**: 1394.

"In anticipation of an opportunity to reassemble the number of deaths from typhoid in each of the 93 cities which have been included in these reports in previous years, and in order to recalculate the rates in light of the 1940 census figures, each health officer was requested to furnish the number of deaths from typhoid, both among residents and nonresidents for each of the last 11 years, 1930 to 1940 inclusive. This procedure demonstrated how difficult is the task of obtaining, for such summary, figures which are altogether comparable with those secured for previous years. Many clerical errors were evident which required much correspondence and, for some cities, the rechecking of local records and original certificates. The practice regarding reallocations has varied both by time and by place, adding to the confusion. It has been our expressed intent to include all typhoid deaths, both resident and nonresident, but in spite of this declaration some health officers have entirely omitted nonresident deaths for allocations made within the state. Common denominators for purposes of comparison cannot be obtained in this way. Now that the death rates have been corrected on the basis of the 1940 census, it will probably be advisable in future reviews to build tables on the basis of resident deaths. This could not be done in the early reviews for want of a common reallocation practice. Some health officers reported cases instead of deaths, but such error became immediately apparent. Less evident was the occasional inclusion of the paratyphoids in spite of instructions to the contrary. Many health officers need pay more attention to statistics sent out from their departments, the accuracy and completeness of which are too frequently left to a casual clerk.

"The estimated population on July 1 of each year, 1930 to 1939, was employed in determining rates. These estimates were furnished by the Bureau of the Census. For 1940 the provisional census data were used, since the Bureau has not made population estimates for cities as of July 1, 1940.

TABLE 1

Typhoid Death Rates per 100,000 Population of 98 Large U.S. Cities, by Geographic Divisions, 1906–40

City	1940	1939	1936–40	1931–35	1926–30	1921–25	1916–20	1911–15	1905–10
New England States									
Worcester	0.0	0.0	0.2*	0.5*	1.0	2.3	3.5	5.0	11.8
Cambridge	0.0	0.0	0.2*	0.8	2.1	4.3	2.5	4.0	9.8
Fall River	0.0	0.0	0.2	0.2	2.2	2.3	8.5	13.4	13.5
Lynn	0.0	0.0	0.2	0.2	1.5	1.6	3.9	7.2	14.1
Waterbury	0.0	0.0	0.2	0.4	1.2	1.0	8.0	18.8	....
Springfield	0.0	0.0	0.3*	1.1†	0.4	2.0	4.4	17.6	19.9
New Bedford	0.0	0.0	0.4	1.1	1.5	1.7	6.0	15.0	16.1
Lowell	0.0	0.0	0.4	1.2	2.6	2.4	5.2	10.2	13.9
Hartford	0.0	0.0	0.5	1.0†	1.3	2.5	6.0	15.0	19.0
New Haven	0.0	1.2†	1.0	0.7†	0.6	4.4	6.8	18.2	30.8
Boston	0.1*	0.4†	0.3†	0.6	1.2	2.2	2.5	9.0	16.0
Providence	1.2	0.4	0.6	1.1†	1.3	1.8	3.8	8.7	21.5
Bridgeport	2.0	0.0	0.4	0.3	0.5	2.2	4.8	5.0	10.3
Somerville	2.0	0.0	0.6	0.4	1.3	1.6	2.8	7.9	12.1
Middle Atlantic States									
Yonkers	0.0	0.0	0.3	0.7	0.5	1.7	4.8	5.0	10.3
Buffalo	0.0	0.2	0.1	0.6	2.7	3.9	8.1	15.4	22.8
Rochester	0.0	0.6†	0.3†	0.4	1.7	2.1	2.9	9.6	12.8
Scranton	0.0	0.7	0.3	1.4	1.8	2.4	3.8	9.3	31.5
Reading	0.0	0.9	0.5	0.4	1.6	6.0	10.0	31.9	42.0
Newark	0.0	0.9	0.3	0.4	0.9	2.3	3.3	6.8	14.6
Utica	0.0	1.0*	0.2*	0.2	1.1	3.9‡	....	....	....
Erie	0.0	1.7†	0.7†	1.2	0.9	2.3	6.9	49.0	46.6
Camden	0.0	2.5*	1.4†	2.7	4.4	5.9	4.9	4.5	4.0
New York	0.1	0.2	0.3	0.8	1.3	2.6	3.2	8.0	13.5
Pittsburgh	0.4	0.4†	0.7	0.9	2.4	3.9	7.7	15.9	65.0
Philadelphia	0.6	0.6†	0.8	0.9	1.1	2.2	4.9	11.2	41.7
Jersey City	0.7†	0.0	0.6	0.3	0.9	2.7	4.5	7.2	12.6
Paterson	0.7	0.7*	0.7†	0.9	1.0	3.3	4.1	9.1	19.3
Albany	0.8*	0.0	1.2†	1.2	1.8	5.6	8.0	18.6	17.4
Elizabeth	0.9	0.0	0.5	0.9	1.6	2.4	3.3	8.0	16.6
Syracuse	1.0*	0.0	0.3*	0.8	0.8	2.3	7.7	12.3	15.6
Trenton	2.4*	0.0	1.4†	1.1	2.1	8.2	8.6	22.3	28.1
South Atlantic States									
Wilmington	0.0	0.0	0.5	1.5	3.1	4.7	25.8‡	23.2‡	33.0
Charlotte	0.0	0.0	1.6†	2.5	....	....	....	....	....
Tampa	0.0	0.9	0.6†	3.4	3.8	19.1	43.9‡	....	....
Jacksonville	0.0	1.8	2.3	1.6	4.4	....	....	....	....
Baltimore	0.3†	0.6†	0.9†	1.4	3.2	4.0	11.8	23.7	35.1
Washington	0.6	0.6	1.1	2.2	2.8	5.4	9.5	17.2	36.7
Atlanta	0.7*	2.3	2.1†	7.3	11.1	14.5	14.2	31.4	58.4
Miami	1.2	1.2	2.4	2.0	3.5	....	....	....	....
Richmond	2.6	1.6	2.5†	2.4	1.9	5.7	9.7	15.7	34.0
Norfolk	2.8†	0.0	1.1†	3.3	2.2	2.8	8.8	21.7	42.1
East North Central States									
South Bend	0.0	0.0	0.0	0.8	....	....	....	....	....
Fort Wayne	0.0	0.0	0.0	2.1	4.2	12.9	7.3	....	....
Milwaukee	0.0	0.0	0.1	0.2	0.8	1.6	6.5	13.6	27.0
Grand Rapids	0.0	0.6	0.5†	0.2	1.0	1.9	9.1	25.5	29.7
Canton	0.0	0.9*	0.4†	0.8	1.4	3.3	8.9	....	....
Youngstown	0.0	1.2	0.7	1.2	1.1	7.2	19.2	29.5	35.1
Peoria	0.0	1.9	1.3†	0.9	0.2	3.7	5.7	16.4	15.7‡
Chicago	0.1	0.3	0.3	0.4	0.6	1.4	2.4	8.2	15.8
Columbus	0.3*	1.0†	1.4†	1.9	2.1	3.5	7.1	15.8	40.0
Detroit	0.3	0.5	0.4	0.7	1.3	4.1	8.1	15.4	22.8

TABLE 1—*Continued*

City	1940	1939	1936–40	1931–35	1926–30	1921–25	1916–20	1911–15	1906–10
East North Central States—*Continued*									
Akron	0.4*	0.0	0.6†	0.9	1.5	2.4	10.6	21.0	27.7‡
Toledo	0.4	0.4*	1.0†	1.2	3.0	5.8	10.6	31.4	37.5
Flint	0.7	0.0	1.3†	0.8	1.6	4.6	22.7	18.8	46.9
Cleveland	0.7	0.6†	0.6	1.1	1.0	2.0	4.0	10.0	15.7
Cincinnati	0.7†	1.1†	1.1†	1.4	2.5	3.2	3.4	7.8	30.1
Gary	0.9	1.8	1.1	0.8	...	...	...	....	....
Evansville	1.0*	1.0*	1.2†	1.8	6.2	5.0	17.5	32.0	35.0
Indianapolis	1.0	1.8†	1.2†	1.8	2.7	4.6	10.3	20.5	30.4
Dayton	2.8	0.0	1.4	0.8	1.9	3.3	9.3	14.8	22.5
East South Central States									
Louisville	0.9†	0.9*	0.9	2.8	3.7	4.9	9.7	19.7	52.7
Chattanooga	1.6	0.0	0.9	5.8	8.0	18.6	27.2	35.8‡	....
Memphis	1.7†	5.9†	4.0†	7.5	9.3	18.9	27.7	42.5	35.3
Knoxville	1.8	4.5	3.8	6.0	10.7	20.8	25.3‡	....	....
Birmingham	3.4†	1.1†	2.5†	4.1	8.0	10.8	31.5	41.3	41.7
Nashville	3.6†	3.0†	3.4†	5.7	18.2	17.8	20.7	40.2	61.2
West North Central States									
Duluth	0.0	0.0	0.2	1.0	1.1	1.7	4.4	19.8	45.5
St. Paul	0.0	0.0	0.3	0.7	1.4	3.4	3.1	9.2	12.8
Wichita	0.0	0.0	0.4	1.1	1.2	6.3	...	....	....
Des Moines	0.0	1.3	1.3	2.5	2.4	2.2	6.4	15.9	23.7
Minneapolis	0.4	0.2	0.2	0.8	0.8	1.9	5.0	10.6	32.1
Omaha	0.4	0.4	0.6	0.9	1.3	3.3	5.7	14.9	40.7
St. Louis	0.4†	0.7†	0.7	1.6	2.1	3.9	6.5	12.1	14.7
Kansas City, Mo.	0.7†	1.0	0.9†	1.6	2.8	5.7	10.6	16.2	35.6
Kansas City, Kan.	1.6	0.0	1.0	1.0	1.7	5.0	9.4	31.1	74.5‡
West South Central States									
Tulsa	0.0	1.4	0.4	1.1	8.3	16.2‡	....	....	....
Oklahoma City	1.0	3.0	2.6	4.3	7.4‡	....	....	....	....
Fort Worth	1.1	0.6*	2.1	4.5	5.9	6.1	16.3‡	11.9	27.8
Houston	1.6	1.6†	2.3	3.2	4.8	7.6	14.2	38.1	49.5‡
New Orleans	2.4†	7.3†	5.0†	9.6	9.9	11.6	17.5	20.9	35.6
San Antonio	2.7	2.4†	2.9	4.3	4.6	9.3	23.3	29.5	35.9
Dallas	3.0†	1.7*	2.7†	5.1	7.3	11.2	17.2	....	....
El Paso	3.1†	6.2*	4.5	5.2	9.1	10.8	30.7	42.8	....
Mountain and Pacific States									
Seattle	0.0	0.3	0.2	0.7	2.2	2.6	2.9	5.7	25.2
Portland	0.0	0.3	0.3	0.8	2.3	3.5	4.5	10.8	23.2
Sacramento	0.0	0.9*	1.5*	6.3	...	....	....	....	....
San Diego	0.0	1.0*	0.8	1.3	1.0	1.6	7.9	17.0	10.8
Denver	0.0	1.9	1.4	1.7	2.6	5.1	5.8	12.0	37.5
Spokane	0.0	2.5†	1.2	1.0	2.2	4.4	4.9	17.1	50.3
San Francisco	0.3†	0.0	0.4	0.8	2.0	2.8	4.6	13.6	26.3
Los Angeles	0.4†	0.3	0.7†	0.8	1.5	3.0	3.6	10.7	19.0
Oakland	0.6*	0.3	0.5†	1.2	1.2	2.0	3.8	8.7	21.5
Long Beach	0.6	0.6	0.5	0.5	1.1	2.1‡	...	....	....
Salt Lake City	0.7*	0.0	0.3*	0.7	1.9	6.0	9.3	13.2	41.1
Tacoma	0.9	0.9	0.5	0.9	1.8	3.7	2.9	10.4	19.0

* All typhoid deaths were stated to be in nonresidents.

† One third or more of the reported typhoid deaths were stated to be in nonresidents.

‡ Incomplete data.

"Paratyphoid has again been excluded. In Table 1 (as well as in Table 2) a special note has been made of cities in which all deaths occur among nonresidents. As far as possible this practice has been applied to all data for the quinquennium 1936–40. Another symbol has been used to indicate those cities in which more than one third of the reported deaths were stated to have been among nonresidents.

"A comparison of deaths reported by the New England health officers shows a consistency in the annual returns made during each of the past five years and the retabulation submitted for this inquiry. There were reported in 1936 eleven deaths, in 1937 twelve, in 1938 twelve, in 1939 six, in 1940 nine, a total of 50 for the quinquennial period. Ten New England cities (Cambridge, Fall River, Hartford, Lowell, Lynn, New Bedford, New Haven, Springfield, Waterbury, Worcester) report no death from typhoid in 1940. In 1939 there were eleven such cities. Fall River, Lynn and New Bedford record no death in four years; Cambridge and Lowell extend their record to three years. Hartford, Springfield, Waterbury and Worcester report no death in two years. Of 18 cities among the 93 in the U. S. recording no deaths from typhoid during the past two years, 9, or one half the total, are in the New England group. Springfield reports no death among residents during the past

TABLE 2

Typhoid Death Rates in 1940

Honor Roll: No Typhoid Deaths (41 Cities)‡

Buffalo	Grand Rapids	Portland	St. Paul
Cambridge	Hartford	Reading	Tampa
Camden	Jacksonville	Rochester	Tulsa
Canton	Lowell	Sacramento	Utica
Charlotte	Lynn	San Diego	Waterbury
Denver	Milwaukee	Scranton	Wichita
Des Moines	Newark	Seattle	Wilmington
Duluth	New Bedford	South Bend	Worcester
Erie	New Haven	Spokane	Yonkers
Fall River	Peoria	Springfield	Youngstown
Fort Wayne			

First Rank: From 0.1 to 1.9 Deaths per 100,000 (43 Cities)§

Boston	0.1*	Omaha	0.4	Kansas City, Mo.	0.7†	Indianapolis	1.0
Chicago	0.1	Pittsburgh	0.4	Cleveland	0.7	Oklahoma City	1.0
New York	0.1	Toledo	0.4	Flint	0.7	Fort Worth	1.1
Columbus	0.3*	Oakland	0.6*	Paterson	0.7	Miami	1.2
Baltimore	0.3†	Long Beach	0.6	Albany	0.8*	Providence	1.2
San Francisco	0.3†	Philadelphia	0.6	Louisville	0.9†	Chattanooga	1.6
Detroit	0.3	Washington	0.6	Elizabeth	0.9	Houston	1.6
Akron	0.4*	Atlanta	0.7*	Gary	0.9	Kansas City, Kan.	1.6
Los Angeles	0.4†	Salt Lake City	0.7*	Tacoma	0.9	Memphis	1.7†
St. Louis	0.4†	Cincinnati	0.7†	Evansville	1.0*	Knoxville	1.8
Minneapolis	0.4	Jersey City	0.7†	Syracuse	1.0*		

Second Rank: From 2.0 to 4.9 (12 Cities)

Bridgeport	2.0	New Orleans	2.4†	Norfolk	2.8†	El Paso	3.1†
Somerville	2.0	Richmond	2.6	Dayton	2.8	Birmingham	3.4†
Trenton	2.4*	San Antonio	2.7	Dallas	3.0†	Nashville	3.6†

* All typhoid deaths were stated to be in nonresidents.

† One third or more of the reported typhoid deaths were stated to be in nonresidents.

‡ 39 without Charlotte and Sacramento.

§ 42 without Gary.

six years, Worcester none for five years. While it was stated in the review for 1939 that Bridgeport reported no death in six years, in light of more recent reports from the health officer, Bridgeport had no death in five years (1935 to 1939). In 1940 there were three deaths in Bridgeport, all among residents. It is stated that a carrier was the source of infection for one death; the other two were traced to the eating of clams dug from polluted waters close to shore. Boston records one death among nonresidents. Of thirteen deaths during the past five years (1936–1940) only three have been among residents. For the quinquennium 1931–35 New Haven reports but one death among residents; for the five years 1936–40 there are six such deaths recorded. While Providence reports but seven deaths (all among residents) for the last five years, three of these deaths occurred in 1940. Likewise, of three deaths during the last quinquennium in Somerville, two are recorded for 1940. The New England cities as a whole (population 2,579,152) have lost first place among the grouped cities (Table 5). The group of Middle Atlantic cities has moved from second to first place, the group of Mountain and Pacific cities occupies second place for 1940 and the New England and East North Central cities tie for third place. For the quinquennial average (1936–40) the New England group continues to hold first place.

"The health officers of the Middle Atlantic cities have not proved as consistent in the reporting of typhoid deaths. On the basis of their annual returns for each of the past five years they report a total of 288 deaths, while in the present retabulation they record but 283 deaths for the quinquennium 1936–40. The first place Middle Atlantic cities have a group rate (0.27) which is lower than that of 1939 (0.37) and 1938 (0.44). Nine cities (Buffalo, Camden, Erie, Newark, Reading, Rochester, Scranton, Utica, Yonkers) report no typhoid death in 1940. In three cities (Albany, Syracuse, Trenton) it is stated that all deaths were among nonresidents. While Utica records no death among residents during the past ten years, it is stated that one death occurred among nonresidents in each of the two years 1935 and 1939. The health officer failed to record such nonresident death in the 1939 report. Yonkers is the only city in this group to report no death for two years. Camden records no death among residents for three years, Albany for two. Buffalo reports but four typhoid deaths for the quinquennum 1936–40, three among residents. Erie also records four deaths during these five years, only one of which was among residents. New York reports eleven deaths, all among residents. For the 1939 review the health officer reported 22 deaths, but in the present survey the 1939 number has been reduced to 17, 15 among residents. It is stated that in the former review the deaths from paratyphoid were inadvertently included. As in other cities in the North, New York does not have an organized campaign of immunization, although such preventive treatments are advised for residents who visit camps or summer resorts where typhoid may be endemic and in families where a case exists or a carrier is discovered. In the 1939 review Paterson was included with the eight cities reporting no death. The health officer now reports one death for 1939 among nonresidents, for 1940 one death among residents. In 1939 Philadelphia reported twelve deaths, only six of which were among residents. For 1940 there are recorded twelve deaths, all but one among residents. During the last five years there were 82 deaths from typhoid in Philadelphia, of which 73 are stated to be among residents. Pittsburgh reports three deaths, all among residents. Rochester reports no death from typhoid, notwithstanding a contamination of a portion of the city water supply in December, at which time about twenty thousand inoculations were given by the health bureau. Syracuse records three deaths (all among nonresidents) during the past five years. In the group as a whole (population 13,129,185) there were 36 deaths in 1940, compared with 48 in the preceding year.

"For the nine cities of the South Atlantic states which have been included in previous reviews, the local health officers now report 182 deaths instead of 184 for the five years 1936–40. The rate (0.73) is

significantly lower than that of 1939 (0.93). Charlotte has been included in the group for the first time; however, for purposes of adequate comparison the figures for this city have been omitted in calculating rates for the group as a whole. Four of the ten cities (Charlotte, Jacksonville, Tampa, Wilmington) record no death in 1940. Charlotte and Wilmington report no death for two years. With seven deaths in 1939, Atlanta reports but two in 1940, both among nonresidents. It is stated that of three deaths in Baltimore two were among nonresidents, and of 39 deaths occurring in this city during the five years 1936–40, 14 were thus classified. Charlotte, a newcomer among the cities of 100,000 population, records eight deaths for the quinquennium, five of which were among residents. Of five deaths in Richmond in 1940, four were among residents; of four in Washington, three were thus classified. In the nine cities (exclusive of Charlotte) there occurred 20 deaths in 1940, 25 in 1939, 48 in 1938.

"To the eighteen cities (population 9,386,378) previously included in the East North Central group has been added Gary, but again the figures for this city have been omitted in the tables for group comparison. For the eighteen cities the health officers report 245 deaths for the five-year period 1936–40, two more than recorded in the previous annual tabulations. It is now stated that in these eighteen cities there were 69 deaths in 1936, 64 in 1937, 34 in 1938, 45 in 1939, 33 in 1940. The rate for 1940 (0.35) is lower than that of 1939 (0.48) and equal to the rate for the New England cities. There are seven cities (Canton, Fort Wayne, Grand Rapids, Milwaukee, Peoria, South Bend, Youngstown) which report no death in 1940. Fort Wayne reports no typhoid death in six years, South Bend no death in five years, Milwaukee no death in four years. In three cities (Akron, Columbus, Evansville) it is stated that all deaths were among nonresidents. Of eight deaths in Akron during the past five years, five were among nonresidents; of two in Canton, one was so classified. Chicago reports only four deaths, all among residents. Of 43 deaths in Chicago during the period 1936–40, all but one were among residents. The Chicago figures do not include the deaths of Illinois residents outside Chicago and may not, therefore, be directly comparable with those of other cities. Cincinnati reports three deaths in 1940, two among residents; Cleveland six, five among residents. Of 22 deaths in Columbus during the quinquennium 1936–40, 12 were among nonresidents. Of ten in Dayton, five were among nonresidents. For 1940 Dayton records six deaths, five among residents; Detroit five, all among residents. Seventeen cases of typhoid in Dayton were traced to a carrier who prepared food for a banquet held in April; later 2 other cases were traced to this same carrier. It is stated that of six deaths from typhoid in Evansville during the past five years, five were among nonresidents; of 24 in Indianapolis, 11 were among nonresidents; of fourteen in Toledo, six were among nonresidents.

TABLE 3

Typhoid Death Rates of Large U.S. Cities, 1906–40

Year	No. of Cities	10.0 and Over	5.0 to 9.9	2.0 to 4.9	1.0 to 1.9	0.1 to 0.9	0.0
1906–10	77	75	2	0	0	0	0
1911–15	79	58	19	2	0	0	0
1916–20	84	22	32	30	0	0	0
1921–25	89	12	17	48	12	0	0
1926–30	92	3	10	30	37	12	0
1931–35	93	0	6	17	28	42	0
1930	93	2	6	30	23	22	10
1931	93	2	6	23	28	22	12
1932	93	1	7	13	29	29	14
1933	93	0	7	18	19	33	16
1934	93	0	9	11	27	23	23
1935	93	0	7	15	18	29	24
1936	93	0	3	15	21	36	18
1937	93	0	1	13	26	26	27
1938	93	0	3	13	14	34	29
1939	93	0	3	7	17	32	34
1940*	93	0	0	12	12	30	39

* Charlotte, Gary and Sacramento omitted.

"The six cities in the East South Central group (population 1,286,747) show a decrease in the death rate (2.09 in 1940; 2.58 in 1939). The health officers now record 161 deaths for the quinquennium 1936–40, two less than recorded in the

TABLE 4

Total Typhoid Rate for 78 Cities, 1910–40 and for 93 Cities, 1935–40*

Year	Population	Typhoid Deaths	Typhoid Death Rate per 100,000
78 Cities			
1910	22,573,435	4,637	20.54
1911	23,211,341	3,950	17.02
1912	23,835,399	3,132	13.14
1913	24,457,989	3,285	13.43
1914	25,091,112	2,781	11.08
1915	25,713,346	2,434	9.47
1916	26,257,550	2,191	8.34
1917	26,865,408	2,016	7.50
1918	27,086,696†	1,824†	6.73
1919	27,735,083†	1,151†	4.15
1920	28,244,878	1,088	3.85
1921	28,859,062	1,141	3.95
1922	29,473,246	963	3.26
1923	30,087,430	950	3.16
1924	30,701,614	943	3.07
1925	31,315,598	1,079	3.44
1926	31,929,782	907	2.84
1927	32,543,966	648	1.99
1928	33,158,150	628	1.89
1929	33,772,334	537	1.59
1930	34,410,235	554	1.61
1931	34,508,750	563	1.63
1932	34,607,505	442	1.28
1933	34,708,945	423	1.22
1934	34,833,650	413	1.19
1935	35,005,351	348	0.99
1936	35,196,325	337	0.96
1937	35,386,380	289	0.82
1938	35,578,011	257	0.72
1939	35,767,022	232	0.65
1940	35,895,638	172	0.48
93 Cities			
1935	37,025,179	385	1.04
1936	37,241,414	366	0.98
1937	37,459,339	324	0.86
1938	37,680,155	298	0.79
1939	37,900,354	259	0.68
1940	38,060,662	190	0.50

* The following 15 cities are omitted from this table because data for the full period are not available: Canton, Chattanooga, Dallas, Fort Wayne, Jacksonville, Knoxville, Long Beach, Miami, Oklahoma City, South Bend, Tampa, Tulsa, Utica, Wichita, Wilmington.

† Data for Fort Worth lacking.

previous tabulations. For 1939 two cities (Louisville, Chattanooga) report no death among residents. While in 1940 there were no cities in this group, four (Louisville, Memphis, Birmingham, Nashville) report that more than one half the deaths occurred among nonresidents (15 of 23). Again the death rate in these urban centers is affected unfavorably by the hospitalization of cases brought in from the surrounding rural areas. Of nine deaths in Birmingham, it is stated that seven were in nonresidents. The proportion for 1940 is much higher than for the five year period (13 of 34). Chattanooga, reporting no death in 1939, records two among residents in 1940; Knoxville two, one among residents; Louisville three, one among residents; Nashville, six, two among residents, one of whom contracted the infection outside the city limits. Reporting seventeen deaths in 1939, twelve among nonresidents, Memphis records but five deaths in 1940, and it is stated that two of these were among nonresidents. The rate for the six cities in 1940 (2.09) is slightly higher than that for the West South Central group (2.00).

"The West North Central group (population 2,716,484) shows a decrease in the death rate from 0.52 in 1939 to 0.41 in 1940. For the five years 1936–40 the health officers record 81 deaths, an increase of two over the total reported in the statistics previously submitted for each of the five years. Originally reporting one death in 1938, Des Moines now records three deaths for that year. The rate for the nine cities (0.41) approximates that (0.35) for the New England and the East North Central groups. Four cities (Des Moines, Duluth, St. Paul, Wichita) record no death in 1940. Wichita reports no death during the past four years, Duluth but one death during the quinquennium 1936–40. Kansas City, Kan., with no death in either 1938 or 1939, reports two among residents in 1940. It is stated that in Kansas City, Mo., there were three deaths in 1940, two among residents; for the quinquennium, eighteen, eleven among residents. Minneapolis reports two deaths in 1940, both in residents; four for the five years 1936–40, three among residents. St. Louis

records three deaths, two among residents.

"The cities in the West South Central group (population 2,048,692) report a very significant reduction in the typhoid rate (3.35 in 1939, 2.00 in 1940). The number of reported deaths dropped from 68 in 1939 to 41 in 1940. A comparison of deaths reported by the health officers in this group of cities shows a similarity between returns made during each of the five years and the retabulation submitted for this inquiry. There were reported in 1936, 79 deaths, in 1937, 49, in 1938, 74, in 1939, 68, in 1940, 41, a total of 311 for the quinquennial period. Tulsa records no death in 1940. In 1939 there was no city without a death, although three (Dallas, El Paso, Fort Worth) reported that all deaths were in nonresidents. It is stated that of nine deaths in Dallas in 1940 six were among nonresidents. Houston records six deaths with no attempt to differentiate between resident and nonresident. Of twelve deaths in New Orleans, seven were among nonresidents. San Antonio reports seven deaths, five among residents.

"To the eleven cities (population 4,186,039) previously included in the Mountain and Pacific group has been added Sacramento, but the figures for this city have been omitted in the tables for group comparison. For the eleven cities the health officers report 123 deaths for the five year period 1936–40, six more than recorded in the previous annual tabulations. It is now stated that in these eleven cities there were 34 deaths in 1936, 33 in 1937, 23 in 1938, 20 in 1939, 13 in 1940. The rate for 1940 (0.30) is lower than that of 1939 (0.48). The group of Mountain and Pacific cities occupies second place for 1940. While in 1938 there were five cities with no death, there were but two such cities in 1939. In 1940 five cities (Denver, Portland, San Diego, Seattle, Spokane) among the original eleven record no death, and two additional cities (Oakland, Salt Lake City) report all deaths among nonresidents. Sacramento likewise reports no death in 1940. It is stated that in Denver there were 23 deaths during the four-year period 1936–39 but no death in 1940. Los Angeles records six deaths, three among residents; 49 for the quinquennium 1936–40, 26 among residents. Sacramento records eight deaths for the five years, all among nonresidents. During the past eleven years (1930–40) there have occurred 43 deaths in this city, and but three of these were among residents. Patients from the delta region south of the city are brought to Sacramento hospitals for treatment. San Francisco records two deaths, one in a nonresident.

TABLE 5

Total Typhoid Death Rate per 100,000 Population for 93 Cities, by Geographic Divisions, 1926–40

	Population	Typhoid Deaths		Typhoid Death Rates				
		1940	1939	1940	1939	1936–40	1931–35	1926–30
New England	2,579,152	9	6	0.35	0.23	0.39	0.70	1.31
Middle Atlantic	13,129,185	36	48	0.27	0.37	0.43	0.80	1.40
South Atlantic	2,727,985	20	25	0.73	0.93	1.14	2.70	4.50
East North Central	9,386,378	33	45	0.35	0.48	0.53	0.75	1.29†
East South Central	1,286,747	27	33	2.09	2.58	2.54	4.81	8.31
West North Central	2,716,484	11	14	0.41	0.52	0.60	1.24	1.83
West South Central	2,048,692	41	68	2.00	3.35	3.09	5.36	7.32‡
Mountain and Pacific	4,186,039	13	20	0.30	0.48	0.60	0.88	1.80

† Data for South Bend for 1925–29 are not available.

‡ Lacks data for Oklahoma City in 1926.

The Honor Roll

"The number of cities with no death from typhoid has increased to 41. In 1936 there were but 18 such cities; in 1937, 27; in 1938, 29; in 1939, 34. In 1939 there were fourteen cities with no typhoid death for at least two years; in 1940 there were eighteen such cities. In Table 2

the cities are grouped in rank. In 1938 and again in 1939 there were three cities in third rank (rate in excess of 5.0); however, in 1940 no city falls in this rank. Less impressive is the fact that in 1940 there are twelve cities with rates in excess of 2.0, while there were but ten such cities in 1939. It should be emphasized that in Trenton all deaths were among nonresidents, and in six of the remaining cities with rates in excess of 2.0 the records indicate that one third or more of deaths were among nonresidents. Nine cities in the first rank (Boston, Columbus, Akron, Oakland, Atlanta, Salt Lake City, Albany, Evansville, Syracuse) would appear (in addition to Trenton) in the honor roll were they not charged with deaths in nonresidents. The downward trend in the rates is shown in Table 3.

"For the quinquennium 1936–40 the cities of the New England States have the lowest rate (0.39), followed in order by the Middle Atlantic and East North Central groups (Table 5). The West North Central and Mountain and Pacific groups have the same rate (0.60). The number of deaths from 1935 to 1940 and the corresponding rates (Table 4) for the 78 cities and also the 93 cities have been corrected in light of the new figures submitted by the health officers and the census data furnished by the Bureau of the Census. For the 78 cities for which data are available since 1910 there occurred 172 deaths from typhoid in 1940, which is the lowest of record (257 in 1938; 232 in 1939). The rate for all cities is now just about one half of one point per hundred thousand of population. No outbreaks have been recorded. Preventive measures have been the same as reported for previous years."

Disease Outbreaks From Water, Milk and Other Foods in 1939. A. W. Fuchs. Pub. Health. Repts. **56**: 2277 (Nov. 28, '41). Most striking fact is that other foods far more prolific source of outbreaks than milk or water. Unsafe water supplies caused far more outbreaks and cases of gastro-enteritis than of typhoid fever or dysentery. Ground water supplies incriminated in 31 of 35 outbreaks for which type of supply reported. In nearly all cases, wells and springs contamd. by sewage or surface drainage. San. control of ground water supplies remains important problem in preventing water-borne disease. Smaller communities had fewer such outbreaks in proportion to their no. than larger cities, but no. persons affected greater in proportion to pop. 32 states failed to report any water-borne outbreaks for '39, whereas nearly half reported by single state. These outbreaks characteristically of summer occurrence. 34 of 43 started in Apr.–Sept. period. Nearly half began in July. Same seasonal distr. common to the 3 diseases reported. Extreme differences between large no. ou - breaks reported by few states and small no., or entire absence of reports, from many other states, out of all proportion to relative pops. Explanation probably lies in efficient epidemiological organization for uncovering outbreaks in reporting states, and their willingness to report them. These states to be congratulated, for their example may encourage neighboring states to improve efforts in this important field.—*Ralph E. Noble.*

A Study of an Epidemic of Brucellosis Due to Brucella Melitensis. I. Forest Huddleson and Myrtle Munger. Am. J. Pub. Health. **30**: 944 (Aug. '40). During the brucellosis epidemic which occurred at Mich. State College in winter of '38–'39, 45 individuals developed clinical form, and possibly 49, subclinical form of the disease. Of 45 clinical cases, 41 were students, 1, stenographer, 1, plumber, 1, stockroom attendant, and 1, salesman. *Brucella melitensis* was cultured from blood of 36 of clinical and 3 of subclinical cases. No other species of *Brucella* involved. All possible sources of infective material responsible for epidemic mentioned and discussed. Has been pointed out that if infecting organisms came through water supply of bldg. due to back-siphonage, certain conditions affecting water supply would have to exist almost simultaneously. No proof obtained that any of conditions necessary for back-siphonage occurred in bldg. during fall and winter of '38. Most convincing evidence in support of hypothesis of mass infection is occurrence of majority of both clinical and subclini-

cal cases in 3 lab. classes. Hypotheses offered to explain source of infective material, when subjected to critical anal., lack sufficient proof to explain how epidemic originated. Results of different lab. diagnostic tests show that no one test always sufficient to confirm diagnosis of clinical brucellosis shortly after onset. Combined results of all lab. tests show that active infection and clinical infection not synonymous. One may be infected with *Brucella* yet never show clinical symptoms of the disease. —*P.H.E.A.*

Pollution of the Rochester, N. Y., Water Supply Through a Cross-Connection, December 1940. (*Published in abstract only.*) J. Bact., **42:** 134 (July '41). *Administrative and Epidemiological Aspects.* PAUL A. LEMBCKE: Poln. of potable Hemlock supply by raw river water from h-p. fire-fighting system not detected by water officials for more than 15 hr., despite receipt of several highly suspicious reports. When city health officer learned of occurrence, public warned in remarkably short time by radio, telephone, sound trucks, newspapers and placards on unprecedented scale. River received raw sewage from over 7,000 people, and sewage variously treated from over 27,000, including 3 known typhoid carriers. From canvass of representative households contg. 1.2% of pop., estd. 30,000 gastro-enteric illnesses of varying severity occurred among 300,000 persons served by Hemlock supply and that use of Hemlock water away from home caused 3,400 illnesses, among 137,000 persons in surrounding area. 5 primary and 1 secondary case of typhoid fever, none fatal, reported. Typing of cultures by bacteriophage showed all 6 strains to be same type—*C.* Although no cases occurred among immunized, nos. were too small to gage preventive effect of typhoid vaccination carried out on large scale subsequent to poln. No evidence to show development of disease was provoked by this measure. *Engineering Aspects.* EARL DEVENDORF: One of most serious emergencies to confront N.Y. State Health Dept. in recent years, in connection with poln. of public water supply, occurred at Rochester, Dec. 11, '40. At this time about 75% of 500-mi. distr. system became contamd. by pumping 5 mil.gal. raw Genesee R. water through accidental opening of valve on unknown cross-connection between munic. fire supply (Holly system) and municipally owned potable public water supply (Hemlock system). As soon as situation became known, water dept. officials immediately arranged for flushing system and installing chlorine apparatus to treat water flowing from reservoirs in effort to sterilize system. These remedial measures found inadequate and finally, Dec. 15 and 16, high-test hypochlorite soln. pumped into distr. system through fire hydrants, using 6 street flushers and 2 fire pumpers. On following day bacteriological examn. of tap water from many points in system indicated latter had been effectively chlorinated and water supply safe.—*Ralph E. Noble.*

CORROSION AND CORROSION CONTROL

Corrosion Control—A Critical Review of Recent Developments. EDWARD W. MOORE. J.N.E.W.W.A. **55:** 265 (June '41). Corrosion control methods in water lines and structures include use of lime, metaphosphates, silicates, limestone or similar filtering materials, and cathodic protection. Objective of lime, or any other common alk. substance to deposit and maint. on pipe thin film of $CaCO_3$ or other substances. Experience with lime treatment has shown tendency for excess $CaCO_3$ deposition at beginning of system and little protection at ends. Introduction of metaphosphates provided means of slowing up early $CaCO_3$ deposition and subsequent pptn. at far ends of system when slow reversion of metaphosphates takes place. Metaphosphates also found to inhibit corrosion through formation of absorbed film on metal; little information so far available whether results altogether due to film or partly also to apparent successful treatment through prevention of pptn. of soluble corrosion Fe products in water.

Silicates used alone and with lime; protective action due to formation of film of silica gel or calcium silicate. When used with lime, film is harder, smoother and more dense. 8 ppm. SiO_2 concn. recommended; too high for h-p. boiler use. Cathodic protection consists of setting up artificial or applied potential voltage opposing soln.-potential of metal; first used in water works in '28. Recently applied to steel standpipes with many favorable reports of results; not, however, used in water lines.—*Martin E. Flentje.*

Causes of Corrosion Currents. R. B. MEARS AND R. H. BROWN. Ind. Eng. Chem. **33:** 1001 (Aug. '41). Lack of uniform attack in electrochem. corrosion probably associated with local potential differences (PD). Impurities in metal of less consequence than commonly supposed. Other sources of PD associated with metal are: (1) Grain boundaries, which form heterogeneous region between two grains or crystals compared with body of grain. Measurements on sufficiently coarse-grained specimens show differences in PD between body and boundary of grain, using various metals and various electrolyte solns. (2) Orientation of grains in different directions possibly produces PD. (3) Theoretically PD should be found between coarse and fine-grained specimens but experimental difficulties have prevented measurements. (4) Differential thermal or metallurgical treatment important cause of setting up PD between two regions. Among causes of PD associated with metal surface are: (5) Surface roughness. Highly polished metal surfaces may exhibit different soln. potential from rough areas, PD decreasing after exposure to soln. (6) Local scratches among most important causes detg. sites of local attack, especially where metal forms adherent and protective films of corrosion product. (7) Cut edges are sites of special weakness because of difficulty of building up protective film over edge, and sometimes because of severe cold working if metal is sheared. (8) Shape of specimens, convex surfaces showing lower hydrogen overvoltages than concave thus perhaps developing PD. (9) Differential strain from any cause. (10) Differential pre-exposure, e.g., previous contact of portions with corrosive agent, resulting in film-free and film-coated areas. Causes of PD associated with liquid in contact with metal are: (11) Differential concn. of electrolyte, an important cause of corrosion currents. (12) Differential aeration, special attack being likely to occur in region of lowest oxygen concn. (13) Differential heating, e.g., due to differences in temp. of liquid in contact with metal. (14) Differential illumination, PD not being due to local heating. PD of 0.1 v. has been measured but corrosion due to this effect has not been reported in practice. (14) Differential agitation of liquid in contact with metal, effect being due both to movement of liquid and to accompanying aeration. (15) Contact with other metals may cause corrosion currents of considerable magnitude (galvanic corrosion) though emf. series not always dependable guide for predicting behavior of any couple in varying circumstances. (16) Externally applied potentials, e.g, stray currents. (17) Complex cells, where several similar anodic or cathodic areas are acting in parallel. In practice, (4), (6), (11) and (12) most frequently det. local sites of attack. Some exptl. date and illustrative cases given.—*Selma Gottlieb.*

A Continuous Calcium Carbonate Saturation Balance Indicator. A. A. HIRSCH. Ind. Eng. Chem.—Anal. Ed. **13:** 811 (Nov. '41). Internal protection of most water pipelines depends mainly upon formation and maint. of thin protective scale high in $CaCO_3$. Tendency of water to corrode metal or lay protective film detd. exptly. by magnitude and direction of changes in alky. and pH when contacted with $CaCO_3$. Assembly described amplifies Enslow continuous flow tube and provides: (1) sufficient length packed column ($CaCO_3$) to assure equilibrium for test water; (2) internal filter to prevent powd. carry-over; (3) companion unpacked column to preserve proper time relationship between original water and stabilized counterpart; and (4) continuous emf. indication by integral concn. cell. Water flows against pos. head to prevent CO_2 release. Ef-

fects of momentary aeration avoided by making measurements within closed path of water travel. Properly heated and insulated, measurements may be made at elevated temps. As single operation requirement, apparatus uses large vol. relatively clear water under pressure. Most effectively used in plants employing simple anti-corrosion treatment (aeration or limestone beds); controlling corrosion with alkali; softening water by recarbonation; and in zeolite installations having low alk. effluent. Detailed description of apparatus and operation given. Has been used only in New Orleans water purif. plant with tap water, lime softened supply from Miss. R. Compared with bottle test, method destroys supersatn. usually from 2 to 7 ppm. of $CaCO_3$ more completely and at the same time provides automatic, continuous and reasonably current information on plant production, and tendency of water to deposit scale.—*Ralph E. Noble.*

Contact Corrosion of Metals. H. Silman and A. Freeman. Sheet Metal Ind. **15:** 173: 1129 ('41). Nature of contact and electrochem. effects considered. Particular refs. made to following metals and alloys: iron and steel, lead, nickel and its alloys, copper, high-copper alloys, zinc, and light alloys. Requirements of inhibitive paints and pastes given. List of metal combinations which do not show increased attack due to galvanic coupling and list of galvanic series in sea water tabulated.—*I.M.*

The Effect of Corrosion on the Mechanical Properties of Metallic Materials, in Particular of Cast Iron. Wilhelm Patterson and Eugen Piwowarsky. Arch. Eisenhüttenw. (Ger.) **14:** 561 ('41). Effects of corrosion in tap water, dilute sea water and sodium chloride solns. on mech. properties of machined and unmachined cast iron contg. 1.6–3.8% carbon detd. and compared with effects on malleable iron and steel St 37. Only slight deteriorating effect on mech. properties of cast iron produced by corrosive attack. Cast iron less affected than other materials.—*C.A.*

Corrosion of 18 8 Stainless Steel in NaCl Solutions. H. H. Uhlig and M. C. Morrill. Ind. Eng. Chem. **33:** 875 (July '41). Under certain conditions, 18-8 stainless steel may fail in contact with NaCl solns. through formation of deep pits. Can be reduced by eliminating D.O., reducing NaCl concn., lowering temp. or increasing to boiling (to boil out D.O.) and keeping pH at 3 or 4 on acid side or in region of pH 12.—*Selma Gottlieb.*

Corrosion of Steel by Steam at High Temperature. L. H. Solberg, G. A. Hawkins and A. A. Potter. Combustion. **13:** 4: 50 (Oct. '41). Oxidation of variety of steels and alloys by steam at temps. up to 1,200°F. and at pressures up to 1,600 psi. measured. Alloy steels of 7% or more chromium very resistant to corrosion, and 18-8 stainless steels showed practically no corrosion in this range. For other steels, corrosion rate increases very rapidly at temps. in excess of 1,100°F.—*T. E. Larson.*

Influence of Stress on the Corrosion Pitting of Aluminum Bronze and Monel Metal in Water. Dunlap J. McAdam Jr. and Glenn W. Geil. J. Res. Natl. Bur. Std. **26:** 135 ('41). Corrosion pits in aluminum bronze generally confined to areas between crystallites of α phase, whereas those in Monel metal similar in appearance to pits which occur in steel; in both these non-ferrous alloys, however, pits much smaller than those in steel, although size and sharpness both increased by cyclic stress. With high combination of stress, cycle frequency, and corrosion time, fissures develop from blunt pits, those in aluminum bronze being generally oblique and those in Monel perpendicular to direction of principal tensile stress. Corrosion-fatigue curves for both alloys of accelerated damage type generally obtained when rate of corrosion controlled anodically; this explains wider ranges of size and sharpness of pits compared with those obtained in steels, corrosion rate of which cathodically controlled. Paper contains numerous stress- and cycle frequency-corrosion time curves and photo-

micrographs showing nature of damage sustained by alloys under various stress and corrosion conditions.—*I. M.*

Effect of Water on Aluminum. H. LICHTENBERG. Korrosion u. Metal. (Ger.) **16:** 251 ('40). General discussion of effect of water compn. on corrosion of aluminum. Corrosion breakdown of economizer constructed of aluminum described in detail. Increased water temp. and presence of copper salts derived from adjoining equip. considered accelerating factors, overcoming protective effect of MBV (chromic oxide) layer.—*C. A.*

Contributions to the Study of Corrosion in Copper Pipes. M. WATANABE. Mitt. Med. Akad. Kioto. (Jap.) **26:** 419 ('39); Zbl. Ges. Hyg. (Ger.) **46:** 30 ('40). In Japan efforts made to replace lead water pipes with copper pipes. As physiol. and pathol. effects of copper not fully understood, not yet certain that copper water pipes harmless to health. Author investigated corrosion of copper by acid, alk., and distd. waters. Found that distd. water attacked metallic copper, and that solns. of caustic soda or potash generally gave protection, most effective concn. being 10^{-3} *N*. Corrosive action of various solns. increased with concn. For solns. of 10^{-2} and 10^{-3} *N*, corrosive action decreased in following order: hydrochloric acid, sulfuric acid, nitric acid, oxalic acid, acetic acid, water, caustic potash, caustic soda. During test, pH of solns. shifted in acid direction. Conditions affecting corrosion of lead more complicated than those affecting copper. Both protective action of alkalis and their slight solvent action on copper and lead can be explained by formation of carbonates and liberation of carbon dioxide.—*W.P.R.*

Results of Corrosion Tests [on Copper Alloys] in Oil Refineries. N. W. MITCHELL. Proc. Am. Petrol. Inst. **21:** III: 64 ('40). Tensile test specimens have been exposed in racks in no. of oil refineries for several yr. Loss of strength more satisfactory measure of corrosion than loss of wt., since it is affected by selective corrosion, pitting, and intercrystalline attack, and no need to attempt to remove corrosion deposits from specimens. Some preliminary test results, illustrating effects of sulfur- and of water-corrosion, recorded. Antimonial Admiralty metal appears immune to dezincification and resists sulfur-corrosion better than does red brass. Behavior of cupro-nickel erratic.—*I.M.*

Testing of Brass Alloys for Dezincification Resistance. F. M. BARRY. Proc. Am. Petrol. Inst. **21:** III: 68 ('40). Resistance of some copper-zinc alloys to dezincification assessed by observing loss of tensile strength of test samples after immersion in 1% aq. soln. of cupric chloride at 27° and 49°C. for periods up to 50 wk. Addn. of 0.05–0.06% of arsenic, phosphorus, or antimony inhibits dezincification of Admiralty metal under conditions of test, but arsenical Admiralty metal and unmodified alloy susceptible to intercrystalline corrosion, particularly at 49°C.—*I.M.*

Testing of Non-Ferrous Alloys for Condenser-Tube Service Under Conditions Simulating Actual Industrial Service. R. W. MOORE AND S. KLEINHEKSEL. Proc. Am. Petrol. Inst. **21:** III: 73 ('40). Loss of weight of tensile test specimens, placed at both inlet and outlet of refinery condensers, provides satisfactory method of evaluating corrosion-resistance of various alloys. Confirmatory tests may be made by observing behavior of tubes of small exptl. condensers. Methods of mounting and placing tensile specimens discussed and description given of constr. of exptl. condensers. Results of tensile corrosion tests in no. of units reported, and possibility of reducing corrosion by changes in operating conditions discussed. Admiralty tubing used in most condenser installations, and generally gives satisfactory service.—*I.M.*

Tests of the Corrosion of Condenser Tubes. ZYUNKITI NAGAOKA, AKITOSHI WATANABE AND TORAWO YONEYAMA. Bul. Inst. Phys. Chem. Res. Tokyo. (Jap.) **20:** 234 ('41). *I. Corrosion of Tubes of Magnesium.* As a preliminary to comprehensive study of condenser-

tube corrosion, tests carried out on magnesium tube to get results quickly. Magnesium tube, which was 1,350 mm. long × 13.5 mm. id., carried distd. water or 0.5% sodium sulfate soln.; sometimes liquid aerated. Conclusions reached: (1) extent of corrosion depends little on whether tube is vertical or horizontal; (2) air bubbles in water increase corrosion greatly; (3) corrosion increases with velocity of water, but does not vary much when amt. of injected air kept const. and water velocity > 1 m. per sec.; (4) extent of corrosion at inlet end, center, and outlet end of tube does not vary so much as in case of ordinary condenser tube; (5) distd. water and sodium sulfate soln. have considerable difference in type and amt. of corrosion caused. Sulfate results in more localized corrosion and pitting.—*I.M.*

Water-Side Corrosion of Refinery Condensing Equipment. B. B. Morton. Refiner Natural Gasoline Mfr. **20:** 209 ('41). Corrosion on water-side of condensers due mainly to electrolytic action caused by contact between dissimilar metals, differences in concn. of corrosion agents, and presence of corrosion products on surface of metal. Cast iron develops graphitic layer on surface due to removal of iron from matrix. Admiralty metal subject to dezincification, pitting and impingement attack. Latter favored by high entrance velocities and presence of foreign solid matter. In most cases, copper-nickel alloys superior to Admiralty. Copper contents over 40% inhibit growth of sea organisms, probably owing to presence of copper in corrosion products.—*C.A.*

The Question of Degassing Condensates of Central Heating Systems Operating Over Large Distances and Also of Water for Hot-Water Supplies. Helmut Richter. Vom Wasser. (Ger.) **14:** 360 ('39–40). In contradiction to report of Ulrich (Gesundh. Ing. (Ger.) **62:** 713, 729 ('39)), Rostex filters in operation over period of 10 yr. gave satisfactory results in degassing of condensates of central heating systems. Steel wool contg. up to 3% Mn used as filter material. Wrought-Fe pipes which had been in use for 10 yr. carrying water treated in this manner in good condition. Lab. tests with pilot filters showed that eff. of filter independent of depth of filter material so long as amt. of filter material per l. of water const. Retention period necessary to remove all O_2 from water satd. with gas, however, function of temp. According to author, Rostex filter method preferable to Na_2SO_3 method for treating heating concentrates, feed water, etc. Superior especially where concn. of O_2 fluctuates widely, in which case would be very difficult to control Na_2SO_3 dosage. Na_2SO_3 method, in which excess of reagent can be used, however, recommended in those cases in which possibility that the treated water will subsequently take up O_2.—*C.A.*

Natural Protection Against Corrosion in Water Mains. Hugo Haupt. Vom Wasser. (Ger.) **14:** 255 ('39–40). No. of cases reported where pipes through which very soft, acid waters, low in salts and high in CO_2 (14–31 ppm.), flowed found to be unattacked by water over period of many years. Such pipes found to have very thin, impervious protective coating. Coatings on Fe and galvanized pipes white; those on Pb pipes somewhat yellow. Anal. of coatings showed them to differ widely in compn., although in all cases constituents of coating other than metal of pipe showed rather const. proportion of P_2O_5. 4 waters tested all showed fairly high $KMnO_4$ consumption (6 ppm.) in view of their low total solids. Appears that presence of phosphate and Fe in water necessary for formation of such coatings, although very slight concns. of these substances sufficient. Explanation offered is that such coatings formed by deposition of double phosphates (probably of Fe and Ca or Fe and Al) soly. of which much less than that of individual salts. Pointed out that deposition from extremely dil. soln. different process from pptn. from more concd. soln. and that colloidal state plays important part in phenomenon. Humus substances, other salts, and other colloids may be absorbed as particles pass through colloidal stage and thus be em-

bodied in coating formed. Coatings always found to contain large amts. of SiO_2. Explanation of part played by SiO_2, however, not yet clear.—*C.A.*

Severe Case of Pitting in 12-Inch Gate Valves. ANON. Eng. News-Rec. **127:** 225 (Aug. 14, '41). Destructive pitting on discharge end of 8 gate valves supplying 20-nozzle aerator at Calaveras Reservoir, San Francisco, has made replacements necessary. Anticipating that such pitting might result from partial vacuum created, single cone valve placed upstream for regulating flow, permitting gate valves to be normally wide open, but vibration led to use of gate valves for flow regulation. Valves installed 9 yr. ago and usual opening was 2–3″. Water passing through valves usually 70–80% saturated with oxygen and pressure on upstream side 50–60 psi. As remedy, short sleeves with 3″ vents inserted into lines next to valve flanges on discharge side.—*R. E. Thompson.*

Calcareous Incrustation Formed on Cascades at the Indiana State Soldiers and Sailors Monument, Indianapolis. ROBERT R. SHROCK, BERNARD VONNEGUT AND HENRY F. HERPERS. Proc. Indiana Acad. Sci. **49:** 169 ('39). Approx. 2-mm. layer of $CaCO_3$ deposit (contg. minor amts. of MgO, R_2O_3, free C and a trace of sulfate and having a sp.gr. of approx. 2.5) formed each summer on lips (thickest at point of drip) of cascade system at monument, where well water contg. 878 ppm. total solids and 153.2 ppm. Ca used with recirculation for about 20 yr. $CaCO_3$ probably pptd. first as aragonite, later changing to calcite. Winter soot seps. clearly yearly strata of deposit.—*C.A.*

Scale and Corrosion Studies. DAVID W. HAERING. Ind. Eng. Chem. **33:** 1361 (Nov. '41). Initial studies in lab.-scale cooling systems demonstrated effect of critical dissolved-solids limits on: (1) scale control; (2) relative effectiveness of scale and corrosion inhibitors; and (3) effects of chloride ion concns. on corrosion rates. Facts disclosed show limitations of corrective materials and need for more study. Scale formation and control influenced by dissolved-solids concn. Lab. synthetic waters produce results identical with natural waters. Glucoside derivatives more effectively inhibit scale or corrosion than hexametaphosphate. Iron content, in water or deposits, not usable for interpreting corrosion rates accurately in recirculating systems. Chloride concns. accurately represent dissolved solids and directly affect corrosion rate in cooling system practice.—*Ralph E. Noble.*

Errata

1. Figure 4C, p. 259, February 1942 JOURNAL, should have the following added at the bottom:

"Prof. J. J. Doland changed the value of k_a to the more convenient form k by multiplying k_a by 100,000."

2. Page 260, Fig. 5, *Ibid.*: *for* "$k = \dfrac{10357}{C^{1.85}D^{4.87}} = 10^5$" *read* "$k = \dfrac{10357}{C^{1.85}D^{4.87}} \times 10^5$."

Application for Preference Rating—Form PD-1A

THE February 1942 JOURNAL contained the complete text of Priorities Regulation No. 3 which now governs applications for individual preference ratings.

That regulation referred to Form PD-1A, the use of which is mandatory after March 15. Facsimile reproductions of the form appear on the following pages. The forms are presumed to be available at any WPB Priorities Division branch office. They can be printed. They are for sale by certain printers. There are four sheets to each form. The A.W.W.A. office will obtain them for any water works executive at the following price:

Single Set	$.07	Fifty Sets	$1.50
Five Sets	.25	One Hundred Sets	2.75
Ten Sets	.35		

Orders will not be filled unless cash or check accompanies the order. This is to reduce office time that would be otherwise required.

Note the following when filling out the forms.

Item 1. The product for which an A.W.W.A. member is applying for rating is "Public Water Supply of ————————."

Item 2. The product—water supply and service—is *essential* to public health and safety in the city served and to all defense activities therein.

Item 4a. Preference Rating Order P-46 governed water works maintenance and repair.

Item 4c. Form PD-1A is to be used when: (1) the A-10 rating under P-46 will not obtain the material when needed; or (2) a minor extension of service is required to meet defense-created demands.

Item 5. Public water supply is not sold to any *single person.* If, however, the conditions which require the extension of service result from activities of a single Government Contract or Agency or a single civilian agency, the questions under 5 (a-e) must be answered.

Item 6. This section will cover nearly all water works requests for extension material, where general increase in demand causes the need for new facilities. This (PD-1A) form may be used to apply for a preference rating on capital equipment, provided that any resulting expansion of

(Continued on page 467)

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WAR PRODUCTION BOARD
DIVISION OF INDUSTRY OPERATIONS
WASHINGTON, D. C.

INSTRUCTIONS FOR PREPARATION OF APPLICATION FOR PREFERENCE RATING (FORM PD-1A)

GENERAL INSTRUCTIONS.—Fill out in triplicate and execute the Certification on the duplicate copy. Retain the triplicate copy and this Instruction Sheet, and send all other copies to the Director of Industry Operations (PD–1A), Washington, D. C.

A *separate* application must be made for *each* class of Material (or Capital Equipment) commonly supplied by a single plant and for *each* Product or *each* use for which such Material (or Capital Equipment) is required. Form PD–1A may not be used to apply for a Preference Rating on requirements for plant expansion or plant construction, nor may it be used when adequate priority assistance is available under Priority Orders. Application forms for plant expansion or plant construction projects (Form PD–200) may be obtained from the Director of Industry Operations, Washington, D. C., or from any Priorities Field Service Office. Form PD–3A (which may be obtained from Army and Navy Contracting and Inspecting Officers) must be used instead of Form PD–1A for assignment of ratings to Army and Navy contracts and contracts of other Government agencies specified in Priorities Regulation No. 3.

APPLICANT means person, firm, or corporation who has placed or intends to place order(s) for Material (or Capital Equipment) for which preference rating is requested.

SUPPLIER means person, firm, or corporation who has received, or will receive order(s) for which preference rating is requested.

PRODUCT means that which is produced from the Material (or Capital Equipment) for which rating is requested.

MATERIAL means raw material, semi-finished, or finished products, not including Capital Equipment.

CAPITAL EQUIPMENT means machinery, equipment, or other implement of production ordinarily acquired as a capital asset not for resale—e. g., machine tools

Number	TO BE ANSWERED ON FORM PD-1A BY ALL APPLICANTS
1	Describe **PRODUCT** to be produced by you from the **MATERIAL** (or **CAPITAL EQUIPMENT**) for which application is made.
2	Explain relationship of **PRODUCT** produced by you to War Program, national welfare, or Government-sponsored programs.
3	If you have pending PD–1 or PD–1A application(s) for *other* **MATERIAL** required to fill the need for which this application is made, list for each such application (*a*) Description of **MATERIAL**, (*b*) Date of Application.
4*a*	If you are operating under any Preference Rating Order(s), "P" Series, applicable to the **PRODUCT** with respect to which this application is made, state ORDER NUMBER(S) and SERIAL NUMBER(S).
b	If not, have you made application for any such Preference Rating Order(s), "P" Series? (Identify.)
c	If you are operating under, or have applied for any such Preference Rating Order(s), "P" Series, explain why present application is made.
5	If **MATERIAL** is required for a *single* Government contract or a *single* civilian order for the **PRODUCT**, state:
a	Name of Government agency or civilian customer.
b	Supply Arm or Bureau (if Government agency).
c	Complete Contract Number (if Government agency) or Purchase Order Number (if civilian).
d	Quantity of **PRODUCT** on contract or on purchase order.
e	Grade of preference rating (if any) assigned to **PRODUCT** on contract or on purchase order.
6	If **MATERIAL** is required for *several* Government contracts or *several* civilian purchase orders for the **PRODUCT**, state:
a	Names of all Government agencies whose contracts are held.
b	Names of *principal* civilian customers whose purchase orders are held.
c	Grade(s) of Preference Rating (if any) assigned to **PRODUCT** on contract(s) or on purchase order(s).
7	State with respect to each item for which Preference Rating is requested:
a	The shipping date(s) promised by **SUPPLIER** *in the absence of* a Preference Rating.
b	Names of **SUPPLIERS** (if any) who have refused to accept APPLICANT'S order.

Number	TO BE ANSWERED ON FORM PD-1A ONLY BY APPLICANTS FOR PREFERENCE RATING ON CAPITAL EQUIPMENT
8*a*	State the following with respect to the department in which **CAPITAL EQUIPMENT** is to be used: *1st Shift* *2d Shift* *3d Shift* 1. Number of men 2. Average weekly hours worked
b	What percent of the total present output of the department referred to in 8*a* applied to Defense Orders?
c	Do you have in use any equipment similar to that for which application is made?
d	If so, what is the average weekly hours of use of equipment referred to in 8*c*?
e	How do you now accomplish the work for which you require the equipment applied for?

☆ 16—98554-1 U. S. GOVERNMENT PRINTING OFFICE : 1943

PD-1A
2/3/42

ORIGINAL

WAR PRODUCTION BOARD

PREFERENCE RATING CERTIFICATE

(TO BE FILLED OUT BY THE APPLICANT)

SERIAL NO. .....

ISSUED TO: .....
(Name of applicant)

....
(Main office address) (Receiving plant address)

ITEMS COVERED BY THIS CERTIFICATE—List for each item:

REQUIRED DELIVERY DATE	QUANTITY EACH SHIPMENT	VALUE EACH SHIPMENT	DESCRIPTION

PRIORITIES REGULATION NUMBER 3 GOVERNS THE ISSUANCE OF THIS CERTIFICATE AND THE PREFERENCE RATING ASSIGNED. ALL OF ITS TERMS MUST BE OBSERVED. THE FOLLOWING INSTRUCTIONS ARE PROVIDED TO ASSIST IN EXTENSION OF PREFERENCE RATINGS:

1. The Preference Rating assigned by this Certificate may be extended only to:
   (a) Deliveries of material which will be physically incorporated into material to be ultimately delivered to the original recipient of the Preference Rating, or to deliveries of material which itself will be ultimately delivered to the original recipient of the Preference Rating, or which will be used, within the limitations of paragraph (*c*) of Priorities Regulation No. 3, to *restore* inventory to a practicable working minimum.
   (b) Material which is neither greater in quantity nor to be delivered on dates earlier than required to make on schedule a rated delivery or, within the limitations of Priorities Regulation No. 3, to restore inventory to a practicable working minimum.
2. The person to whom this Certificate is issued shall retain it, and he and each related Supplier and Subsupplier may extend the Preference Rating assigned herein to his purchase order(s) by executing and transmitting to his Supplier(s) by endorsement on purchase order or other equivalent document, the following form of Certification, which shall constitute a representation to the Director of Industry Operations.

(The following form of Certification is to be used when endorsing purchase order(s). Do not fill in on this Certificate.)

"CERTIFICATION

"Preference Rating ..... is hereby applied pursuant to Certificate PD-1A, Serial No.(s) .....
in accordance with Priorities Regulation No. 3, with which I certify I have complied.

(Address) (Applicant, Supplier, or Subsupplier)

(Date) (Signature and title of official)"

(TO BE FILLED OUT BY THE DIRECTOR OF INDUSTRY OPERATIONS.)

THE FOLLOWING PREFERENCE RATING IS HEREBY ASSIGNED TO THE ITEMS IN THE QUANTITIES COVERED BY THIS CERTIFICATE:

E.O. 9024, Jan. 16, 1942, 7 F.R. 329, E.O. 9040, Jan. 24, 1942, 7 F.R. 527, sec. 2(a), Public No. 671, 77th Congress, Third Session, as amended, 3 by Public no. 89, 77th Congress, First Session.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1942 16—26896-1

PD-1A
2/2/43
ORIGINAL

APPLICATION FOR PREFERENCE RATING

TO: DIRECTOR OF INDUSTRY OPERATIONS, *Washington, D. C.*

Number	IDENTIFY *EACH* STATEMENT BY NUMBER WITH CORRESPONDING NUMBER ON INSTRUCTION SHEET

(Do not write below this line. If necessary, continue statement (in triplicate) on additional sheet(s) in the same size and form.)

PD-1A
2/2/43
DUPLICATE

APPLICATION FOR PREFERENCE RATING

TO: DIRECTOR OF INDUSTRY OPERATIONS, *Washington, D. C.*

Number	IDENTIFY *EACH* STATEMENT BY NUMBER WITH CORRESPONDING NUMBER ON INSTRUCTION SHEET

The undersigned hereby certifies that he is authorized to execute this application on behalf of the Applicant; the quantities and Required Delivery Date(s) specified are not greater nor earlier than necessary for completion on time of above specified contract(s) or order(s); the facts herein set forth, or appended, are true and correct to the best of his knowledge and belief.

By .....
(Legal name of applicant) (Signature and title of official) (Date)

Section 35 (A) of the United States Criminal Code, 18 U. S. C. A. 80, makes it a criminal offense to make a false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

16—28316-1

PD-1A
2/2/43
TRIPLICATE

APPLICATION FOR PREFERENCE RATING

TO: DIRECTOR OF INDUSTRY OPERATIONS, *Washington, D. C.*

Number	IDENTIFY *EACH* STATEMENT BY NUMBER WITH CORRESPONDING NUMBER ON INSTRUCTION SHEET

(Do not write below this line. If necessary, continue statement (in triplicate) on additional sheet(s) in the same size and form.)

(*Continued from page 464*)

productive capacity does not involve the renovation of old, or the construction of, new buildings. When such renovation or construction is involved, an application for a project rating should be made on forms PD-200 and PD-200A.

Item 7. This must be answered as fully as possible—keeping in mind that *practically no water works construction, maintenance or repair item can be obtained without a preference rating.*

No major extension item can be obtained without a preference rating. If the A-10 rating (for maintenance, repair, operation, minor extension) under P-46 is not high enough to obtain delivery of the items needed, form PD-1A must be used and Item 7 is the heading under which reference must be made to the failure of A-10 rating to obtain delivery.

Applications cannot be considered unless they are properly signed at the *bottom of the first page of the copy marked "Duplicate"*—and not in the space marked "Certification" on the back of the sheet.

Chlorination of Water; Protection of Water Plants

A. W. W. A. Board of Directors Resolutions

TWO resolutions made by the A.W.W.A. Board of Directors at its January 19–20, 1942 Meeting are reproduced in full below for the reference of the water works field. These were sent all A.W.W.A. Members under date of January 30 in a direct mailing. Copies of these resolutions were filed with the Office of Civilian Defense, the War Department, and the Federal Bureau of Investigation. The Secretary's simple letter of transmittal to the FBI was extended by certain comments as follows:

"There has been, as you doubtless know better than I, some tendency on the part of certain agencies to issue orders to water works and other utility executives related to protection against sabotage which have not been as broadly considered as the circumstances merit. The Board of Directors therefore felt that a considered statement of opinion placed in the hands of each member of the Association might be useful both in pointing out to such members the importance of protection of water works properties when the area served is critical and also to point out to the agencies who might contact water works superintendents the importance of considering relative levels of protection rather than flat requirements of the severest nature in all communities."

Acknowledgments were received from all three governmental divisions named above. The complete text of the acknowledgment from the FBI is reproduced in facsimile at the close of the presentation of the resolutions. Readers of the JOURNAL are strongly advised to consider carefully the implications of the second paragraph of Director Hoover's letter.

Chlorination of Water

[The Board of Directors of the American Water Works Association at its annual meeting on January 19–20, 1942, gave extended consideration to certain recommendations that have been made concerning the increase in the amount of chlorine applied to public water supply during the present emergency conditions. It adopted the following resolution as a statement of policy.]

WHEREAS, A recommendation that chlorine residuals be in all cases carried throughout water distribution systems has recently been brought to the attention of the A.W.W.A.,

WHEREAS, Experience here and abroad does not indicate that such a general requirement is practicable under many conditions, nor necessary; nor is it adequate protection against sabotage of water distribution systems;

Therefore, be it *Resolved*, That the Board of Directors of the A.W.W.A. express their disapproval of a general requirement that chlorine residuals be carried throughout all water distribution systems; but

WHEREAS, In communities housing defense industries or military encampments, there is greater damage from sabotage or from other type of damage to public water supplies under present conditions than in normal times,

Be it further *Resolved*, That in addition to the usual safeguards for water supply systems, the following protective steps should be assured for supplies furnishing water to communities housing defense industries or military encampments:

1. Chlorination of surface water sources, except where the existing safeguards *and* historical records of the plant warrant the omission of such treatment,
2. Chlorination of ground water sources when local conditions indicate the necessity for so doing,
3. Provision of standby chlorinating equipment as a safeguard against interruption of treatment,
4. Where chlorination is practiced, maintenance of such chlorine residuals at the point of treatment as are indicated by experience to be adequate, and the making of frequent chlorine residual tests at the point of treatment;
5. Provision made for local disinfection in distribution systems when breaks occur or where special hazards exist.

Protection of Water Plants

[The Board of Directors of the American Water Works Association at its annual meeting on January 19–20, 1942, gave consideration to the protection of water supply properties against sabotage and danger incident to military action; and authorized the following statement of its considered opinion.]

Protection of water supply works against sabotage is a matter of prime importance. While the overseas record during the present war, as well as in the first world war, discloses few acts of sabotage against water supplies, planning and organization for protection against such form of enemy action must not be neglected. Conditions in the United States and its

territorial possessions differ from those existing in Europe and the British Isles. Therefore the situation existing in each region under consideration needs to be reviewed with competent authorities. The protective measures need to be adjusted to the problems that these same competent authorities feel are likely to exist in that particular region or city.

Water works administrators are likely to be held ultimately responsible for the protective measures established. But it should be remembered that the U.S. Army, the Federal Bureau of Investigation, the Office of Civilian Defense and the U.S. Public Health Service, as well as the various state agencies, maintain an interest in the protection of civilian services such as water supply to the degree that the particular civilian service under consideration is related to the field of interest of each federal or state agency.

Although it may be felt highly desirable that water supply executives should be able to look to a single official agency as authority for methods of protecting water service, that is not possible under the present rapidly developing wartime conditions. Experience with real emergency conditions will, without doubt, lead to the designation of a single agency to control such matters.

The extent of protective measures necessary varies with the size of the community and the extent of defense production or military activity in the area served. The small community with no defense activity needs nothing more than good common sense management and operating control. The water supply for communities housing defense industries or serving military centers will need as full protection as a rational consideration of the situation indicates to be necessary.

While no fully authoritative statement of the nature of, or extent of, protective measures is now available, there are certain considerations and objectives relating to protection of water services that are quite definite:

1. The loyalty of employees of a water department must be beyond question. A complete personal record of each employee including an officially filed fingerprint record should be developed. This record should include former employees, particularly any recently discharged.

2. All persons employed about water plants should carry identification cards. Such cards should be regularly used.

3. Visiting at water plants or on water department property should be limited to persons who have been furnished a pass—good only for a single occasion.

4. As fully as practicable, critical parts of the water plant should be fenced or barred against entry of unauthorized persons. The doors of all pumping stations, purification plants and similar structures should be locked at all times. Distribution of keys should be restricted to a limited number of trusted employees.

5. Protective lighting should be installed at key points on the property where the other measures do not suffice. It must be remembered that protective lighting will not be functioning when a blackout occurs. Its value as a protective measure, therefore, must not be over-estimated.

6. Spare parts for critical materials and equipment should be stored at a location not affected by the same hazard as the units to which the spare parts apply.

7. Water department executives should cooperate with state and local police and state and local police should cooperate with water department executives to the end that critical points in water works systems are known to competent police authority. Attention can be given to such critical points by roving police patrol units and more efficient as well as economical protection be thus achieved.

8. Consideration of the need for special guards about water works property resulted in adoption of the following statement by the American Water Works Association's Board of Directors in a meeting held on January 20, 1942:

WHEREAS, Experience abroad has not indicated the necessity for maintaining an elaborate and costly guard of all water works plants, and

WHEREAS, A careful survey may be necessary to insure the most effective measures of protection within reasonable limits of costs, and

WHEREAS, Guarding of vulnerable points may be effected by permanent guards or roving patrol the efficiency or economy of which only such a survey will show,

Now therefore be it *Resolved*, That it is the recommendation of this Board that each person or body responsible for the operation of a water supply system cause to be made a confidential survey of water works structures under their supervision to ascertain the points of vulnerability so that protective measures both in equipment and personnel can be effected to the extent necessitated by local requirements.

All of the above presumes that the municipality or water company will, as a matter of good management procedure under present wartime conditions, already have provided:

Complete maps of the water system in the control of key trusted employees;

Crews trained for emergency repair of breaks in the distribution system;

An understanding developed with other utilities making the repair services of each available to all when necessary and as practical;

Valves in good working order (as shown by test, not by guess) and in such locations as to control significant sections of the distribution gridiron as well as strategic points in supply lines;

A routine of tests of hydrants which assures their readiness to serve in emergency;

A reasonable inventory of repair material, stored in areas away from point of use, ready for repairs to the supply and distribution system.

Nothing in the above list of things presumed to be already complete, should if yet undone, be undertaken now, if the undertaking involves substantial additions to the property and requires a significant amount of metals such as iron, copper and the like. Protective fencing, barring, lighting, etc. must be undertaken if they are recommended by responsible military or counter-espionage authority.

JOHN EDGAR HOOVER
DIRECTOR

Federal Bureau of Investigation
United States Department of Justice
Washington, D. C.
February 20, 1942

Mr. Harry E. Jordan
Secretary
American Water Works Association
22 East 40th Street
New York, New York

Dear Mr. Jordan:

I wish to acknowledge receipt of your letter of February 7, 1942 and its enclosures. Your courtesy and interest in furnishing me with a copy of the memorandum reflecting the action taken by the Board of Directors of the American Water Works Association at its annual meeting concerning protection of water works against sabotage are indeed appreciated.

You may be assured of the fullest cooperation of this Bureau in all matters of mutual interest, and it is urged that the personnel of all water works departments which are represented in the American Water Works Association be encouraged to immediately communicate with the Federal Bureau of Investigation in the event of any occurrences coming to their attention which indicate possible violations of the Federal Espionage or Sabotage Statutes.

Sincerely yours,

J. Edgar Hoover

Emergency Procedure Under Mutual Aid Plans

Following a conference in Washington with members of the staff of the Power Division of the War Production Board, a letter was written to J. A. Krug, Head of the Power Division, which read in part as follows:

"The Mutual Aid Plan for Water Service is a voluntary activity growing out of recent emergency organizations for catastrophes. The plans briefly amount to this. Under the leadership of the State Sanitary Engineer, State Water Co-ordinator, or similar official working in co-operation with the State Council for Defense, the public water utilities are drawn together into regional groups and into state groups organized to extend to each other emergency aid in the form of materials, equipment or personnel. The plan involves a development of a detailed inventory of maintenance and repair material and equipment and the assembly of these inventories both in each region within a state as well as upon a statewide basis. The intention is simply this—that when a break of any nature occurs in one water system and that system does not have the material that it needs to make the repair, it will make its needs known to the regional or state co-ordinator. He will refer to the master inventory and, finding the material in the possession of some other water department, arrange for the loan of it to the department having the emergency to meet.

"This is in effect a voluntary procedure that has commended itself very greatly to water works executives who are faced with the necessity of compensating for their inability to obtain repair material as promptly from manufacturers as was previously possible. This co-operative movement merits encouragement because, among other things, it will tend to reduce the aggregate amount of maintenance and repair materials that water utilities would be inclined to maintain against emergency needs under current delays in procurement.

"There is one impediment to the wholehearted acceptance of the Mutual Aid Plan. Water utilities having the necessary replacement material in their inventories are reluctant to make this material available to the neighboring utility which is in need unless they can have the assurance that the Power Division will grant to the loanor an emergency preference rating that will make it possible for him to replace immediately in his stock the item which he has made available to his neighboring utility. Under the terms of Amendment #2 to Preference Rating Order P-46 the existence of such emergency has been recognized by the War Production Board. Without going to the extent of formalizing the situation by a further amendment to P-46, I am suggesting that you address to this office a communication along the lines suggested in the attached draft. That communication can then be circulated by this office to all state sanitary engineers, state water co-ordinators and executives in the water works field and remove the present impediment to full acceptance of the mutual aid plan."

Statement of Policy

When a mutual aid or similar plan for co-operative emergency maintenance and operation of water works properties has been set up under appropriate authority in any state, the Power Division of the War Production Board will facilitate these activities in accordance with the following understanding.

1. The necessity of emergency maintenance repair to water works property as a result of fire, flood or other climatic or unpredictable conditions is recognized by the terms of Section (F) (4) (v) of Amendment No. 2 to Preference Rating Order P-46.

2. When, under such emergency conditions, it becomes necessary for a water department or utility to obtain such emergency maintenance or repair material, it may:

2.1. Make a telegraphic request of the Power Division, War Production Board, Washington, D. C., for emergency preference rating for the needed material, or

2.2. Obtain the needed material, under "mutual-aid" procedure, by loan from a neighboring water utility.

3. Any public water department or company which has in its stock of reserve materials any item required by, and not in the stock of, another public water supply system, may make the needed material available to the neighboring utility in accordance with the mutual aid plan in effect in that state.

4. When one water utility has made emergency maintenance or repair material available to another under mutual aid procedure, the state or district water coordinator shall file with the Power Division of the War Production Board a telegraphic request for an emergency preference rating or ratings to cover the purchase of the item or items taken from stock. The request shall record (1) the nature of the emergency, (2) the material used, (3) the location where installed and (4) the name and address of the department or utility from whose stock the material was obtained. The preference rating will be granted to the water utility from which the necessary material was obtained so that its reasonable inventory may be maintained and the state or regional plan for emergency maintenance of necessary public water supply service facilitated.

Under date of February 21, 1942, a reply to the letter that had been written to J. A. Krug was received from W. L. Cisler, a member of his staff:

"Reference is made to your letter of February 4, 1942. The potential value of the Mutual Aid Plan for Water Services is appreciated.

"The suggestions indicated with your letter of February 4th are in accordance with proper priorities procedure.

"The value of material loaned by a Producer should be treated as a deduction from that Producer's records of acceptance of deliveries. The Producer to whom the material is loaned is entitled to accept delivery and make withdrawals of such materials if necessary, using the provisions of Paragraph (f) (4) (v) of Preference Rating Order P-46 as amended.

"Materials and equipment loaned may be replaced in stores or inventory under the provisions of Order P-46 or by filing PD-1A applications."

Acting Director H. A. Gray, Office of Solid Fuels Coordination, requests by special letter, received too late for complete presentation, that the Association ask all coal consumers: to order coal immediately so that all transportation facilities now available may be employed; to refrain from using cars to store coal; and to continue to add to coal reserves whenever possible, not so much, perhaps, to protect themselves as to permit maximum use of transportation facilities whenever they are available. **(See release on page 8 of the News of the Field.)**